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MODERN METHODS OF SEWAGE DISPOSAL.*

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The short time at my disposal this afternoon will only allow of a few casual remarks upon a subject which could only be dealt with fully and intelligently in a course of several lectures.

Recent research work and the published reports of the findings of several commissions in Europe and the States, enable one to classify data on the subject of Sewage Disposal; and, further, to crystallize certain defined deductions. It will be my endeavor to-day to attempt to put before you what I understand to be the deductions which can be drawn, based upon present knowledge. I will first address a few general remarks to you, and then throw on the sheet views illustrating several of my points, and the various parts which make up a modern sewage disposal plant.

What exactly is this question of sewage disposal?

We find throughout parts of Europe, especially in Great Britain, and the United States of America, huge sums of money have been, and are now being spent, not only in investigation work, but in installing a variety of plants, some more or less successful. The problem, experimental and otherwise, has been before the greater part of the civilized world for over forty years and is now in a practical form before the people of this country.

The term "Sewage Disposal" has by custom come to mean some applied method of dealing with sewage, so that little or no nuisance will result from its ultimate discharge. Sewage Disposal is the product of the "Water Carriage System" of sewage drainage. Before the "Water Carriage System" came into vogue, what we then understood as sewage was dealt with by the "dry pail" or some such system of collection. Now, however, with the adoption of the "water carriage system" sewage may be defined as simply the water supply of a community after it has been used for a multitude of cleansing purposes. In short the water supply after it is contaminated and mixed with the bulk of human and trade waste which it is necessary to discard daily.

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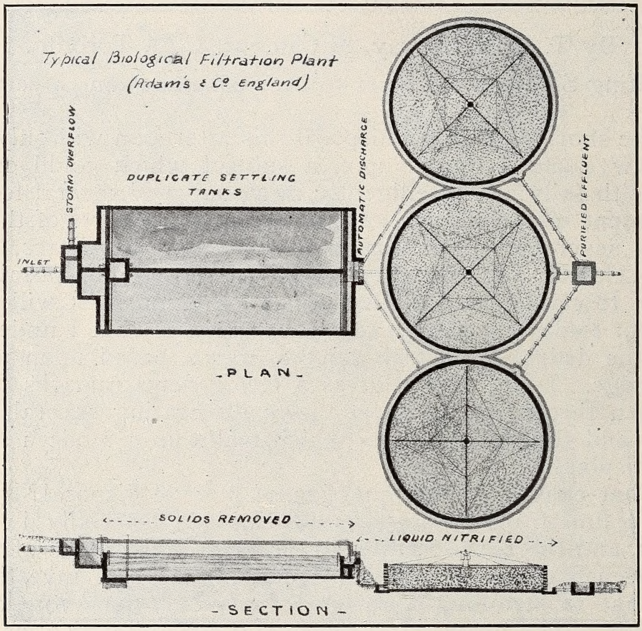
*Paper read before Engineering Society, Nov., 1909.

The necessity of sewage disposal is the direct result of the acknowledgement of a communal responsibility or duty. It is necessary that a community borrow from nature's supply a quantity of clear water, it cannot destroy or use up this water, but must eventually return it to nature. If, before returning the borrowed water, no reasonable method is adopted of removing the greater part of the impurities gathered by contact with a community, it has been found that the sum total supply of water in any country deteriorates and the general community suffer. Hence the question of the prevention of the pollution of streams and waters generally, has been recognized by national and state restrictive laws.



A Modern Sewage Plant

Sewage, or discarded water supply, if untreated by any method of sewage disposal, may either be left to soak into the ground in the vicinity of buildings, and, as often happens, near wells; or it may be carried to some distance by underground channels or pipes, and discharged into some natural drainage source, such as a stream or lake. In all cases, however, it must go somewhere, and carry with it all the collected town filth, until such filth rots out of organic existence, either in the interstices of the earth, is oxidized in a running stream or lost by dilution in some large body of water. That all this filth is eventually changed into harmless products by nature itself, no doubt exists. But the point is, shall we allow this rot and decay of organic filth to take place in our open streams or in the earth supplying ground air to our dwellings, or shall we confine the graveyard to some particular location where the process of oxidation rendering the organic matter stable may be accomplished under direction and supervision, and to the avoidance of any general nuisance to the community. It is admitted on every hand that the filth contained in sewage is not only a danger to the community directly producing it, but also to any community which may come into contact with the eventual discharge.

Now what can we really do with this sewage in order to render it practically harmless and confine the process of purification within a ringed fence.

Nozzle Spray Filter Bed at Hamilton, Ont.

First: What is this sewage? Most of you may have observed it as it empties from an outlet sewer into a stream or other location of discharge. As far as appearance goes it just looks like grey dirty wash water, with occasional floating solids of excrement, paper, corks, orange peel, etc. If the sewer is a short one, with a good gradient, there will be a large amount of these solids apparent. On the other hand, if the sewer is a long one with flat gradients, a very small amount of solids will be observed, as in the latter case they will be broken up and mixed with the liquid, or have undergone a certain amount of decay or rot during the period retained in the sewers. In fact, in modern sewage disposal language, the sewage will have undergone septic action in the sewers previous to discharge. In either case, however, whether the sewage is fresh delivered or is in a semi-rotten state of putrefaction, the apparent grosser solids can easily be removed by simple straining. All that is required is a small chamber provided with vertical gratings which will keep back the grosser solids and only allow the dirty grey looking water to discharge.

This operation of retaining the solids by means of a mesh strainer is the first or primary process in all sewage disposal plants, no matter what the ultimate method of purification may be.

When an analysis of crude sewage is presented it generally refers only to the dirty grey liquid minus the grosser solids.

Now let us suppose that this glass of water which I have in my hand represents the dirty grey liquid after the grosser solids have been removed by straining.

If this sample of average domestic sewage is from a water closet town with a per capita water supply of about 35 gallons per day, an analyst would probably tell us that it contained about 40 parts per 100,000 of suspended solids of which about half was organic and the other half mineral, about 80 to 100 parts per 100,000 of solids in solution, about 4 parts of ammoniacal nitrogen, and that it was capable of absorbing from 10 to 12 parts of oxygen in about 4 hours. In fact, that the glass of liquid was almost a breathing thing, absorbing oxygen and eliminating carbon dioxide. He would further tell us that an ordinary thimble filled with the liquid would produce colonies of bacteria anywhere in number around a figure of 5,000,000.

Now if we let this glass of dirty grey water stand for an hour or two, a thin layer of sediment will form on the base of the glass. This sediment represents approximately from 70 to 80 per cent. of the suspended solids which the analyst has defined. The reason why this sediment has formed is that so much of the solids is heavier than water. Part of the solids will be found to rise to the surface because they are lighter, and part will remain in the body of the liquid because their specific gravity is so near that of water. Now no matter how much longer we allow this glass of liquid to stand, no greater amount of suspended solids will settle out, unless we add to the liquid some re-agent, precipitant or coagulant. Even then the whole of the suspended solids will not be removed. The water will still remain dirty and grey looking.

The above process is, generally, the second one in sewage disposal. It follows straining, and precedes any attempt at purification in the sense of chemical change. The process is called "sedimentation."

Both straining and sedimentation may be said in a sense to purify the sewage, inasmuch as the resultant from both processes is weaker in organic matter than the crude sewage. With the retention and settlement of the solids much organic matter is removed and great numbers of bacteria extracted from the liquid. As sludge, however, the solids still remain to be dealt with. They must be either dried, burnt, buried, or allowed to remain and rot away by septic fermentation. It is in the latter sense that the septic tank comes into action. The ordinary sedimentation tank is transformed into what is called a septic tank, by allowing this settled sediment to accumulate and rot, with the object of its total elimination. It is now, however, being recognized that the adoption of this process has objectionable features. Only about 25 per cent. of the settled solids are so eliminated, and further the liquid sewage constantly passing over a fermenting plane of putrefying sludge gathers up the sludge into itself, and consequently in time the amount of solids in the liquid effluent from the tank is about equal to the amount in the influent sewage.

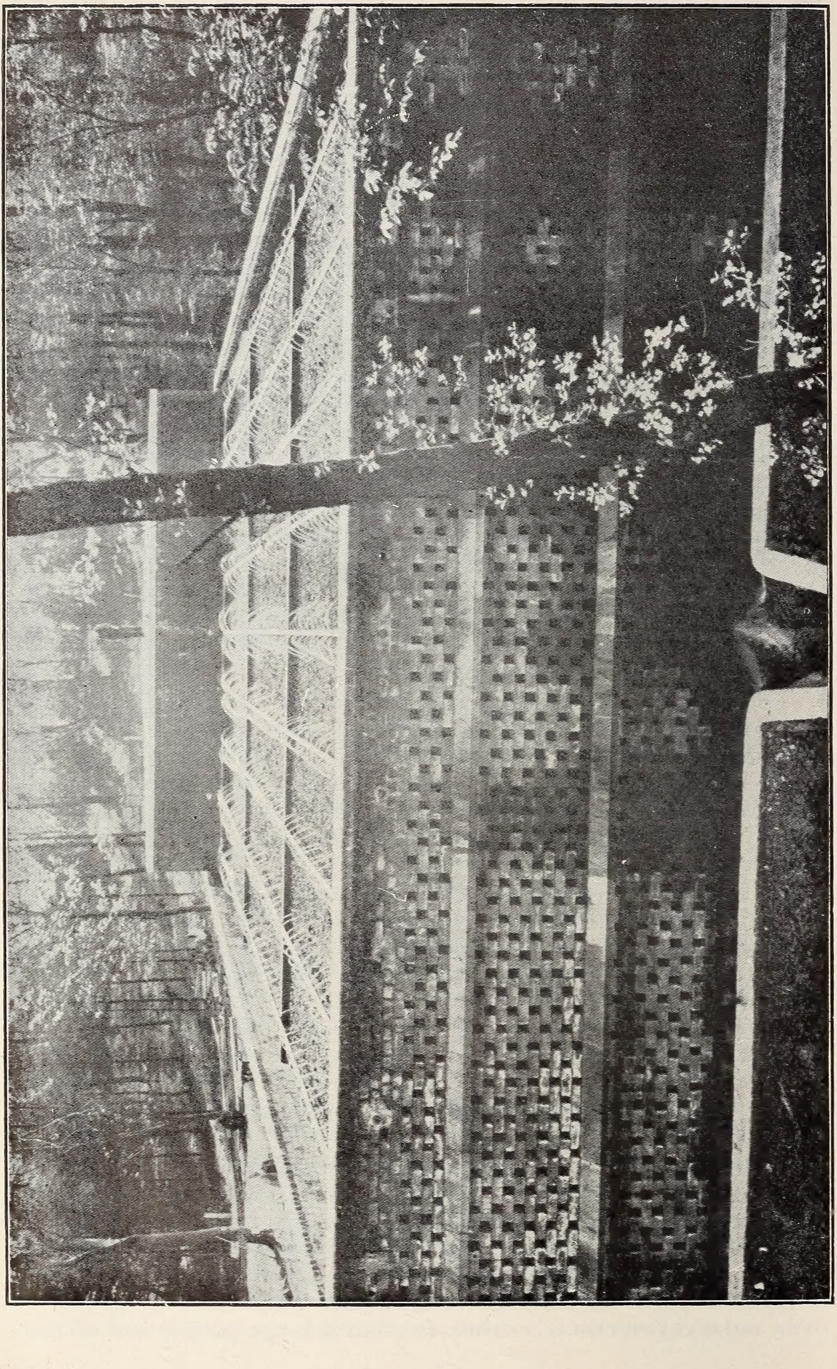
Modern methods for removal of solids mostly include some device for the removal of the settled solids as quickly as possible from contact with the liquid sewage.

It is really only the dirty grey liquid that we require with not more than about 20 to 30 per cent. of the total solids remaining in it, and we should have this liquid as fresh as possible, and not depleted of any of the available oxygen it may contain.

The main point, however, which I wish to lay stress upon is that septic action was never intended as a means of purifying sewage, but simply as a means of getting rid of the sludge difficulty. To many the term "septic tank" stands for sewage purification. It means nothing of the kind.

So much then for what can be done by straining and sedimentation. We will, further, now suppose that we have decanted the grey dirty liquid and left the sediment behind. If we pass this liquid through a layer of filter paper, the first passage will make little or no appreciable difference to turbidity, but if we repeat the process several times, the liquid becomes quite clear. It has all the appearance of ordinary water, loses its dirty grey color, and, in fact, looks drinkable. All the suspended solids, or practically all, have now been removed. This process is called "mechanical filtration," or in sewage disposal language, "clarification." In the sense of removal, but not of purification as far as any chemical change to the organic matter is concerned, the sewage will now on analysis prove weaker in organic strength. A further percentage reduction of bacteria has been effected; in fact, all the bacteria which were contained in the solids have been removed by passage through the filter paper.

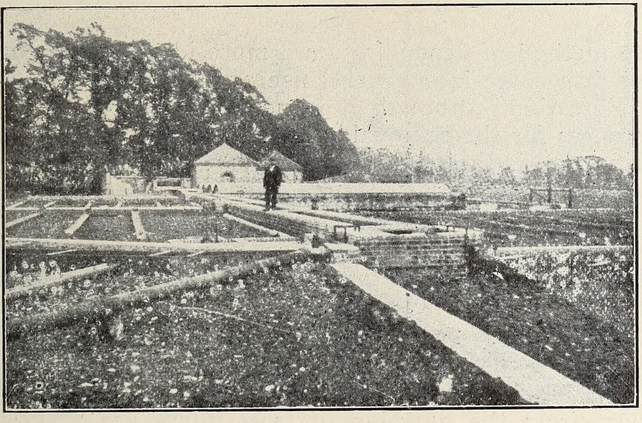
We have now a glass of apparently clear water. Now this glass of water which represents a product after straining, settlement, and mechanical filtration is still in every sense of the term sewage. Let us re-submit this clarified liquid to an analyst, he will have no difficulty in pronouncing it to be sewage. He will tell you that it contains bacteria to the number of somewhere over 100,000 per cubic centimetre, that a large proportion of the



Fixed Pipe Sprays Distributing Sewage Liquor over Percolating Filter bacteria are peculiar to the intestines of animals; that it contains a large amount of organic matter in solution; that it is capable of absorbing about from 7 to 8 parts per 100,000 of oxygen in 4 hours, in fact that it is a fair sample of sewage minus solids in suspension.

We do not require, however, to go to the analyst to find out that there is something radically wrong with this apparently clear water. If we let the glass stand for a time the water will again become turbid, and thread-like film growths will appear. It will undergo putrefaction by the decomposition of the organic matter in solution. If allowed to stand long enough, the analyst could no longer pronounce it sewage, but might say it was polluted with sewage, because he finds the products of decomposed organic matter present. To render a sewage effluent stable by oxidation is called "The Removal of Putrescibility."

A great deal of study has been given to, and a great deal written about "The Removal of Putrescibility," which in ordinary language means the purification of sewage in an accepted sense. Suffice it to say, that this process of fermentation by which organic matter is rendered partly inorganic is called "Nitrification" because the organic nitrogen is first changed by fermentation into nitrous acid, and then oxidized into nitrites, and nitrites into nitrates (by the nitrifying bacteria).



First Contact Beds, Sutton Surrey, England

The practical question in sewage disposal is, shall this process of oxidation or removal of putrescibility be allowed to take place as putrefaction in our streams and creeks, with all its attendant nuisance from smells, discoloration of water, and danger to health, or shall we take the matter in hand and see to it that the sewage is rendered non-putrescible before allowing it to run free.

If we determine to take the work in hand, we will find that the natural soil, granted plenty of it, of an open and friable nature, is the best and most efficient machine for the purpose. However, suitable land is difficult to obtain, and usually it is not sufficiently porous to allow of both liquid retention and air retention necessary to oxidation or nitrification. Further, in Canada one might just as well discharge sewage onto a concrete surface as on to soil in winter time, and nitrification ceases during frost.

A mechanical filter, however, can be constructed which will not only act as a strainer such as the filter paper, but will act also as a nitrifying medium. The question is mainly one of choosing a filtering material which will provide both water retention capacity and air capacity at the same time, so that every drop of sewage as it passes slowly through the filter will be in constant contact with oxygen. Any material such as soil used as a sewage filter is de-aerated and becomes what is called sewage sick, allowing an accumulation of organic matter which is retained unoxidized, and only subject to anaerobic decomposition.

The method of depending on a more ideal filtering material than soil has come into general use and has been named "Biological Filtration" although it is no more biological than any other process for the removal of putrescibility where fermentative nitrification is the reductive factor.

The process is entirely suited to a cold climate, because the works or filter take up very little room, and can be controlled in cold weather by coverngs or heat provision. To put the question of area in a nutshell, a population of 24,000 with a water consumption of 60 gallons per head per day would require an area from 76 to 288 acres of land for soil treatment, while only .88 of an acre in area of filter 6 feet deep would be required for biological treatment.

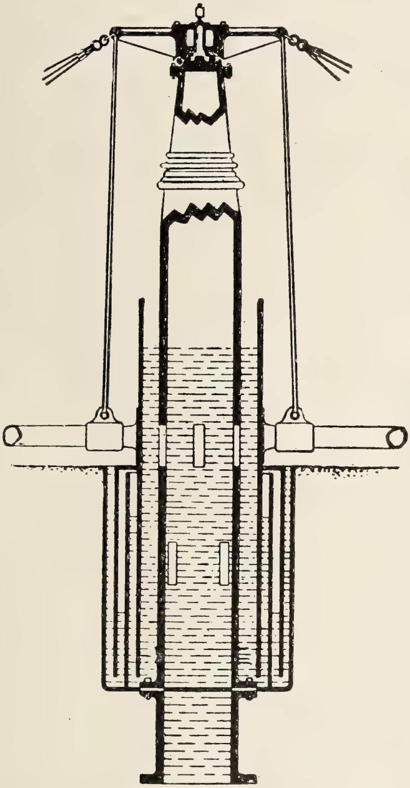
Apart from the question of frost, there are other reasons which appear to favor the installation of filters of a mechanical type. Even with the very best of land there are many cases of failure, although for the first few years good effluents may be produced. Examples exist in the State of Massachusetts where intermittent land filtration gave high efficiencies at first with a gradual falling off as the land became sewage sick.

The efficiency of a biological filter depends greatly on the method adopted of distributing the sewage over the surface area. Illustrations will be shown you of two of the principal methods employed, namely by the use of fixed sprays and revolving sprinklers. Fixed sprays as adopted at Columbus, Ohio, and other places in the States, as well as at a few plants in Great Britain cannot be said to be a success. This method of distribution does not in practice provide equal distribution of the sewage over the surface, in fact, parts of the filter bed receive as much as ten times the sewage as other parts, while only about

60 per cent. of the bed is wetted at any time. The concensus of opinion appears to be in favor of some form of revolving distributor, an illustration of which is produced.

These distributors of the revolving type can be made to work by power derived from the sewage itself, by collecting the sewage in a small dosing tank fixed about 18 inches above the level of the filter bed and feeding the sewage intermittently by aid of a syphon.

Biological filter plants have been constructed on two systems. The one "the contact system," and the other the "continuous percolating system." The percolating system is in every sense superior to the contact system, as with the latter air is excluded for a time from the filter-bed, and the filters become anaerobic or simply septic tanks. With the former air being always present, an equilibrium as between retention of organic matter and oxidation can be maintained resulting in continuous nitrification.



Revolving Distributor (Adam's Crescent)

To recapitulate we have divided sewage disposal into three stages, viz.:—

(a) Straining out the grosser solids.

(b) Retaining a proportion of solids by sedimentation.

(c) Rendering the liquid from (b) non-putrescible by mechanical filtration combined with a process of oxidation.

What about the non-putrescible effluent resulting from (c) process? Is this drinking water, or even fit to mix with a drinking water? By no means; what has been done is all that at the present time is generally asked of any community. The sewage in the chemical sense of the term is stable, resulting odors and general nuisance have been eliminated. What has been done is to render it possible for any community to use a water, receiving the sewage effluent, as a source of water supply, provided that the water is treated by slow sand filtration, or by some other water purification process.

Purification of sewage cannot be said to be complete unless disinfection is adopted as the fourth or final process. That disinfection is a practical method of dealing with sewage has been clearly demonstrated by valuable experiments carried out in the United States, the results of which have only recently been published.

Sterilization or disinfection, however, cannot economically be viewed as a substitute for any of the processes (a), (b), and (c), but only as an adjunct or fourth process. It appears necessary in order to economically and efficiently sterilize a sewage effluent, that most of the suspended matter be removed and that the liquor be rendered non-putrescible by preliminary treatment.

Just how far it is necessary to adopt all of the above processes in one combined sewage disposal plant, depends entirely on what are the particular conditions to be dealt with. The character and size of the body of water receiving the effluent will generally prove the ruling factor in determining the amount of purification required. Cases will occur where simple straining or straining and sedimentation may be sufficient, or in extreme cases it may be necessary to even go as far as disinfection. In the majority of cases, however, it will be found that the discharge of an effluent rendered non-putrescible will meet ordinary conditions and requirements.

The purity of river water is not only affected by sewage effluents, but contamination may arise, and does arise from a variety of causes, especially from unit discharges, which it is generally difficult to control. River water should always be treated by some method of purification before being used as a domestic water supply. It does not, therefore, appear necessary to duplicate final treatment, but it does appear right and fair that a community sufficiently purify a sewage effluent to an extent, which makes final treatment of a water supply a practical possibility.

I regret that the short time at my disposal has only allowed me to casually skim over a large and most interesting problem. The whole subject of the removal of putrescibility in its chemical and biological features is like a tale from fairyland, and certainly deals with a world which is not in an ordinary sense in evidence. The chemist and the bacteriologist are now giving acute attention to the subject of sewage disposal. I will, with your permission, bring these few remarks to a close by advising any of you who intend to take up this special feature of engineering work to make yourself well acquainted with the sciences of organic and inorganic chemistry, and of bacteriology.

A NEW MOMENT TABLE.

C. R. YOUNG, B.A.Sc., A.M. CAN. SOC. C.E.

The analytical determination of shearing forces and bending moments in girders and trusses due to moving locomotive and train loads has been much facilitated by the use of moment tables, but with the tables in general use it is still necessary to perform considerable calculation in obtaining the live load stresses in a structure, especially for those cases where a portion of the uniform train load is on the span.

Thus, referring to the commonly specified live loading for railway bridges, two conventional consolidation locomotives coupled together and followed by a uniform train load, the moments commonly listed are only those about successive wheels for all the loads to the left of each wheel and these moments are carried only to the beginning of the uniform load. Since the right-hand support of the girder or truss generally falls in between two wheels or somewhere along the uniform load, increments have to be added to the quantities listed in the ordinary moment table to give the moment about the right support. Where no uniform load is on the span, the desired moment is obtained by taking from such a table the moment of all the wheels to the left of the first wheel from the right support about that wheel (see Fig. 1) and increasing it by the total load on the span multiplied by the distance between the right support and the first wheel from that support. If a portion of the uniform load is on the span as in Fig. 2, the moment about the right support is found by taking from a table of the usual form, the moment of all the wheels on the span about the beginning of the uniform load and increasing it by the sum of the wheel loads on the span multiplied by the distance between the beginning of the uniform load and the right support and also by the moment about the right support of the portion of the uniform load on the span. The calculation of these increments again and again involves a loss of time which may be obviated by the use of a sufficiently comprehensive moment table.

With the object of thus shortening calculations for shear and moment due to moving locomotive and train loads the accompanying table, Fig. 3, in which the moments are given about successive points one foot apart, is herewith submitted. The loading chosen is one used extensively in Canada, Class 1, Dominion Government Specifications, 1908. Moments for other classes may be derived from the table by multiplying the quantities given therein by the ratio of the uniform train load of the class under consideration to that of Class 1. Similar tables may be readily computed for the loadings of other specifications.

In preparing the table special care has been taken to arrange the quantities given in the most convenient manner for easy and rapid reading of results. Above the wheels are given the distances between wheels in feet and the loads for one rail, in thousands of pounds, or kips. Below the wheels are given the distances in feet from the first wheel of points one foot apart up to 209 feet, the sum of the loads from the left up to and including the wheel load under consideration and the moment of all loads to the left of, and about, points one foot apart, up to 209 feet from the first wheel. Lines connecting these quantities to the proper points on the base line facilitate the reading of the results from the table while the use of especially heavy lines at the wheels and at points ten feet apart along the uniform load serves to mark the table off into divisions, thus making the location of a given point easier than if lines were all of the same weight. Staggering of the quantities, contributes to the legibility by reason of the large size which can thus be given to the figures. One hundred feet of uniform load is included in the table in order to make it applicable for maximum reaction calculations to all spans up to 200 feet.

The amount of shortening of computation effected by the use of the new table over the less extensive one can be seen best by considering some typical examples.

Let it be required to find the live-load shear at the quarter-point in a girder of 72-foot span with wheel 2 of the loading for which the table is prepared at the point (Fig. 1). Assuming that the table contained only the moments about successive wheels of the loading, the shear, V, at the point being equal to the left-hand reaction minus load 1, is found thus:

$$V = \frac{5508.0 + 182.7 \times 6}{72} - 12.15$$

$$= 79.575 \text{ kips.}$$

With the table as prepared in Fig. 3, the calculation would be:

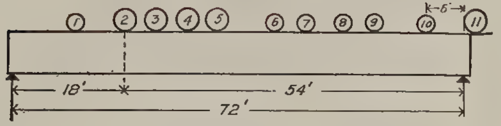


FIG. 1

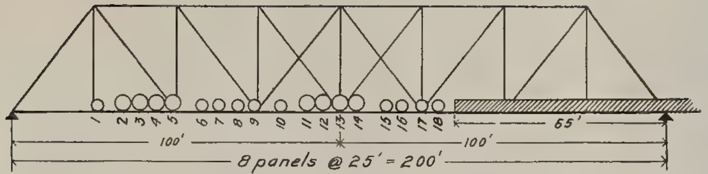


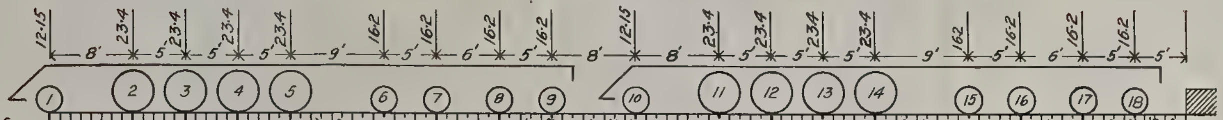
FIG. 2

MOMENT TABLE

FOR **ONE** RAIL

CLASS I LOADING, DOMINION GOVERNMENT SPECIFICATIONS, 1908

Loads in kips. Distances in feet. Moments in kip-feet.



Distances from first wheel	Sum of loads	Moments of all loads to left
0	12.15	0
1		12.15
2		24.30
3		36.45
4		48.60
5		60.75
6		72.90
7		85.05
8	35.55	97.20
9		132.75
10		168.30
11		203.85
12		239.40
13	58.95	274.95
14		333.90
15		392.85
16		451.80
17		510.75
18	82.35	569.70
19		652.05
20		734.40
21		816.75
22		899.10
23	105.75	981.45
24		1087.20
25		1192.95
26		1298.70
27		1404.45
28		1510.20
29		1615.95
30		1721.70
31		1827.45
32	121.95	1933.20
33		2055.15
34		2177.10
35		2299.05
36		2421.00
37	138.15	2542.95
38		2681.10
39		2819.25
40		2957.40
41		3095.55
42		3233.70
43	154.35	3371.85
44		3526.20
45		3680.55
46		3834.90
47		3989.25
48	170.55	4143.60
49		4314.15
50		4484.70
51		4655.25
52		4825.80
53		4996.35
54		5166.90
55		5337.45
56	182.70	5508.00
57		5690.70
58		5873.40
59		6056.10
60		6238.80
61		6421.50
62		6604.20
63		6786.90
64	206.10	6969.60
65		7175.70
66		7381.80
67		7587.90
68		7794.00
69	229.50	8000.10
70		8229.60
71		8459.10
72		8688.60
73		8918.10
74	252.90	9147.60
75		9400.50
76		9653.40
77		9906.30
78		10159.20
79	276.30	10412.10
80		10688.40
81		10964.70
82		11241.00
83		11517.30
84		11793.60
85		12069.90
86		12346.20
87		12622.50
88	292.50	12898.80
89		13191.30
90		13483.80
91		13776.30
92		14068.80
93	308.70	14361.30
94		14670.00
95		14978.70
96		15287.40
97		15596.10
98		15904.80
99	324.90	16213.50
100		16538.40
101		16863.30
102		17188.20
103		17513.10
104	341.10	17838.00
105		18179.10
106		18520.20
107		18861.30
108		19202.40
109		19543.50

2.25 kips per lineal foot

Distances from first wheel	Sum of loads	Moments of all loads to left
109	341.1	19543.50
110	343.35	19885.725
111	345.6	20230.20
112	347.85	20576.925
113	350.1	20925.90
114	352.35	21277.125
115	354.6	21630.60
116	356.85	21986.325
117	359.1	22344.30
118	361.35	22704.525
119	363.6	23067.00
120	365.85	23431.725
121	368.1	23798.70
122	370.35	24167.925
123	372.6	24539.40
124	374.85	24913.125
125	377.1	25289.10
126	379.35	25667.325
127	381.6	26047.80
128	383.85	26430.525
129	386.1	26815.50
130	388.35	27202.725
131	390.6	27592.20
132	392.85	27983.925
133	395.1	28377.90
134	397.35	28774.125
135	399.6	29172.60
136	401.85	29573.325
137	404.1	29976.30
138	406.35	30381.525
139	408.6	30789.00
140	410.85	31198.725
141	413.1	31610.70
142	415.35	32024.925
143	417.6	32441.40
144	419.85	32860.125
145	422.1	33281.10
146	424.35	33704.325
147	426.6	34129.80
148	428.85	34557.525
149	431.1	34987.50
150	433.35	35419.725
151	435.6	35854.20
152	437.85	36290.925
153	440.1	36729.90
154	442.35	37171.125
155	444.6	37614.60
156	446.85	38060.325
157	449.1	38508.30
158	451.35	38958.525
159	453.6	39411.00
160	455.85	39865.725
161	458.1	40322.70
162	460.35	40781.925
163	462.6	41243.40
164	464.85	41707.125
165	467.1	42173.10
166	469.35	42641.325
167	471.6	43111.80
168	473.85	43584.525
169	476.1	44059.50
170	478.35	44536.725
171	480.6	45016.20
172	482.85	45497.925
173	485.1	45981.90
174	487.35	46468.125
175	489.6	46956.60
176	491.85	47447.325
177	494.1	47940.30
178	496.35	48435.525
179	498.6	48933.00
180	500.85	49432.725
181	503.1	49934.70
182	505.35	50438.925
183	507.6	50945.40
184	509.85	51454.125
185	512.1	51965.10
186	514.35	52478.325
187	516.6	52993.80
188	518.85	53511.525
189	521.1	54031.50
190	523.35	54553.725
191	525.6	55078.20
192	527.85	55604.925
193	530.1	56133.90
194	532.35	56665.125
195	534.6	57198.60
196	536.85	57734.325
197	539.1	58272.30
198	541.35	58812.525
199	543.6	59355.00
200	545.85	59899.725
201	548.1	60446.70
202	550.35	60995.925
203	552.6	61547.40
204	554.85	62101.125
205	557.1	62657.10
206	559.35	63215.325
207	561.6	63775.80
208	563.85	64338.525
209	566.1	64903.50

BARBER & YOUNG,
BRIDGE AND STRUCTURAL ENGINEERS
TORONTO.

FIG. 3

$$V = \frac{6604.2}{72} - 12.15 = 79.575 \text{ kips},$$

thus shortening the work sufficiently to effect a saving of time in a number of such computations, much greater than the time taken in listing the moments for the intermediate points between the wheels.

Again, let it be required to find the live-load moment, M, at the centre panel point of a truss (Fig. 2) of 200-ft. span made up of 8 panels of 25 feet each, with wheel 13 at the point. Employing the concise form of moment table in common use, the calculation would be:

$$M = \left(\frac{19543.5 + 341.1 \times 65 + \frac{1}{2} \times 2.25 \times (65)^2}{200}\right) \times 100 - 9147.6 = 14086.5 \text{ kip-feet.}$$

Employing the more extensive table this becomes:

$$M = \frac{46468.125}{200} \times 100 - 9147.6 = 14086.5 \text{ kip-feet.}$$

Where the right-hand support falls in between the points an even foot apart, results sufficiently accurate may be obtained by interpolation.

In testing for maximum shear and moment, where a portion of the uniform load is on the span, a saving of time is also effected by being able to read directly from the table the total load on the span for any assumed position of the loading.

RAILROAD LOCATION.*

W. G. SWAN, B.A. Sc.

Of men who find their way into railroad engineering only a very small percentage take up the location branch of the work. This is natural enough, since the demand for locating engineers is comparatively small. Every construction engineer who follows this line of work will, however, find it greatly to his advantage to have a competent knowledge of railroad location gained only by experience in the field. Revision of the located line usually falls to the lot of the man on construction. If the engineer would do this to best advantage he must have a thorough knowledge of location work.

The locating engineer should understand fully the conflicting interests which are to govern his choice of a route. Very little ability in this branch of work is required to locate a line which could be constructed, and over which trains could be operated. What is desired generally, however, is the best line which will give, if possible, cheapness in construction as well as cheapness in operation. Where the choice in locaton is free from political or other allied interests, the three important factors governing this choice are the initial cost of construction, the operating expenses per train mile, and the proximity of the line to centres of trade. The initial cost should be a minimum, the operating expenses per train mile should be a minimum, and the location of the line should be such that the greatest amount of traffic will find its way over the company's lines. To maintain a low initial cost, especialy in rough country, will invariably mean heavy grades and sharp curvature. Heavy operating expenses will naturally accompany this class of construction. We have at once two conflicting interests which bear on the selection of a route. The happy mean might solve the difficulty, and probably does in some cases, but the greatest factor in the solution will always be the financial status of the construction company.

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*Read before the Civil Section of Engineering Socieiy, Nov. 1909.

Cuts of this article courtesy "Canadian Engineer".

Pack Train leaving Junction of North Thompson and Clear Water Rivers, B.C.

On this account the engineer should be given to understand fully the allowable first cost of construction, that he may not select a line which will be beyond the means of his company, and which might later be rejected because of prohibitive cost. Ample time should always be allowed for the selection of the best possible route, since the cost of location forms but a very small portion of the total expenditure necessary to construct the railroad complete for operation.

Before taking the party into the field it is altogether advisable that the locating engineer go over the proposed route, making what is known as a reconnaissance survey. Not infrequently a whole party is placed in the field to make the reconnaissance survey. This is generally conceded to be a mistake. It leads invariably to backing up, re-running line, and adds materially to the total cost of obtaining a final location. Very often where a choice of routes is considered an able man will see in going over the ground the superiority of one route over a second. When no such apparent superiority exists, the engineer in making his reconnaissance will decide upon the necessity of running alternate survey lines with his party in the field. The reconnaissance survey made by the locating engineer before taking his party into the field will always present the results which arise in the blind running ahead of the initial survey through unknown country, where without warning a "dropping off" or "stepping up" place is encountered by which, or through which, the construction of a line would be a physical impossibility. Prior to setting out upon this reconnaissance survey it will be of invaluable aid to the engineer to procure the latest and most up-to-date maps of sections of the country through which the proposed line will run. "A fund of valuable information will often be obtained from this source." The most reliable topographical maps should be taken into the field on all occasions and consulted frequently. In England, where the Ordinance Department has prepared with utmost care topographical maps of all portions of the country, the location is projected in the office on these maps, their accuracy being such as to make it unnecessary, except in unusual cases, to place any survey party in the field. Furthermore, the engineer will find it profitable on his reconnaissance to have accompany him, if possible, some one who is acquainted with the particular section of country under consideration. Usually an aneroid barometer, a surveyor's box compass, and possibly a hand level will be sufficient in the way of mathematical instruments for the necessary observations. A record of all information likely to be of value later on should be kept during this survey.

The reconnaissance completed, the engineer is now in a position to organize his party for the field. The preparation necessary for taking a party into a settled section to locate is small in comparison with that required prior to taking a party into a rough, unsettled district. The make-up of the party in each case will be about the same, but the question of outfit and supplies necessary for carrying on work in an unsettled section of country is no small consideration. In settled country it will be found more economical to have the party board at small hotels and farm houses along the route, since camp equipment always necessitates a large outlay for the usual party of from twelve to eighteen men. The locating engineer, or chief-of-party, as he is usually termed, should either know personally the men he is about to take into the field or have them well recommended. An incompetent man is frequently retained on a party simply because the distance to market is too great to permit the getting of a new man. Trouble to the same extent will not, of course, be experienced in working through settled country. While there probably exists no healthier occupation in healthy climates than railroad location work, yet it is not a sick man's occupation.

It is healthy work only for a healthy man. One of our reliable texts on railroad work says: "The man on location work will probably work from 14 to 16 hours per day." This seems to be placing figures at their maximum value, but there is no question as to hours being long, the work heavy, and hardships not a few. I venture to say, however, that where conditions are not beyond human endurance, no day seems half so short as a busy day spent in the field on location work.

A few words here with regard to the personnel of the party to be taken into the field to make the preliminary and final surveys. It has been said of the chief-of-party that his only duty is to keep his eyes open. While this is probably of greatest importance, he must have a thorough knowledge of the duties of each man of his party (preferably gained by having occupied at various times the individual positions) in order that he may know whether or not accurate and conscientious work is being done. He must have the sympathy and good-will of his party to obtain best results, and this will be gotten only in return for his own. He must be capable if he would hold their respect; should have good control of his temper, a little righteous indignation not being out of place at the right time. He should not find it necessary to stand on his so-called dignity to keep his men in what he would consider rightful places. The competent man will get best results with greatest harmony in his party. He should not work his men on Sundays, nor call rainy days Sundays and work the next Lord's Day which comes along. There is usually plenty of work for a rainy day in camp.

The transit-man is the chief's right-hand man, and should always wherever possible act up to it. He should be rapid and accurate with his work, especially in rough country, where set-ups are frequent and difficult. He should not be called upon to run line and do transit work at the same time; his work is very exacting, and he cannot under such conditions do justice to either. He must not try to put it over his men if he would get best results. Don't feel big because you are the transitman, or, at least, don't let anyone know it if you do. They say you don't need to when you are chief.

The leveller, like the transitman, should work quickly and accurately. In his levelling he should check his turns in the field and establish his bench-marks only on his checked calculations. If the checking be left until reaching the office at night an error might be found which would necessitate changing the marked elevations on bench-marks perhaps for miles back.

The topographer should be a man competent to take reliable, accurate and intelligent notes, and should be able to work rapidly if he would keep pace with the rest of his party.

The rodman and chainman should be active, careful and intelligent men, who have an interest in their work. In open country the progress of the party will depend largely upon the rate of travel of the chainmen. The chainmen, or, perhaps, to be more specific, the head chainman, is the pace-maker. Never let a lazy man occupy head chainman's position, nor anyone who, perhaps, through no fault of his own, cannot walk rapidly.

The field draughtsman should be neat, rapid and accurate with his work; should be something of a specialist and mind-reader, to be able to decipher all field notes which are turned into the office.

Hell Gate, North Thompson River, B.C.

The Fore-picketman, who is usually one of the axemen, should be able to run a straight line through the bush without continual aid from the transit. His eyesight should be good to permit his taking signals from the transitman. The rear-picketman's post, in the writer's opinion, is bset left vacant. A good cross-head, firmly set, is always available, though some times picked up with difficulty from the transit; but a rear picketman, when he is wanted, who can find? Do not of necessity choose the axeman who can chop the biggest tree in the shortest length of time. Select the man who is willing to take his chance in both pleasant and unpleasant work. Class number one probably represents, or is represented by, the lumber-jack. The wise chief will have no place on his party for the lumber-jack. He is all right just so long as he can stand on the high and dry ground and chop the big trees, but when it comes to cutting out the underbush in the wet places he is found wanting. He is, furthermore, a born grumbler; pass him up. It has been said in the Good Book the last shall be first. This will undoubtedly apply to the cook. Unless he be of that variety who accepts cook's position on a party as a means of obtaining an outing. The chief should select a cook of whom he has a personal knowledge, or who comes recommended at first hand. The writer has in mind a case where the cook learned to make bread at some friend's place the night before he accepted cook's position on the party. At the end of a week the cook tried to sell out to one of the axemen, whom he learned understood something of cooking. At the end of the second week he was not given the option of selling out; he was put out. A party has been run for weeks with the chief laid up or absent, but never for more than one day with the cook and assistant off the job. He runs the chief a very close second for first place on the party.

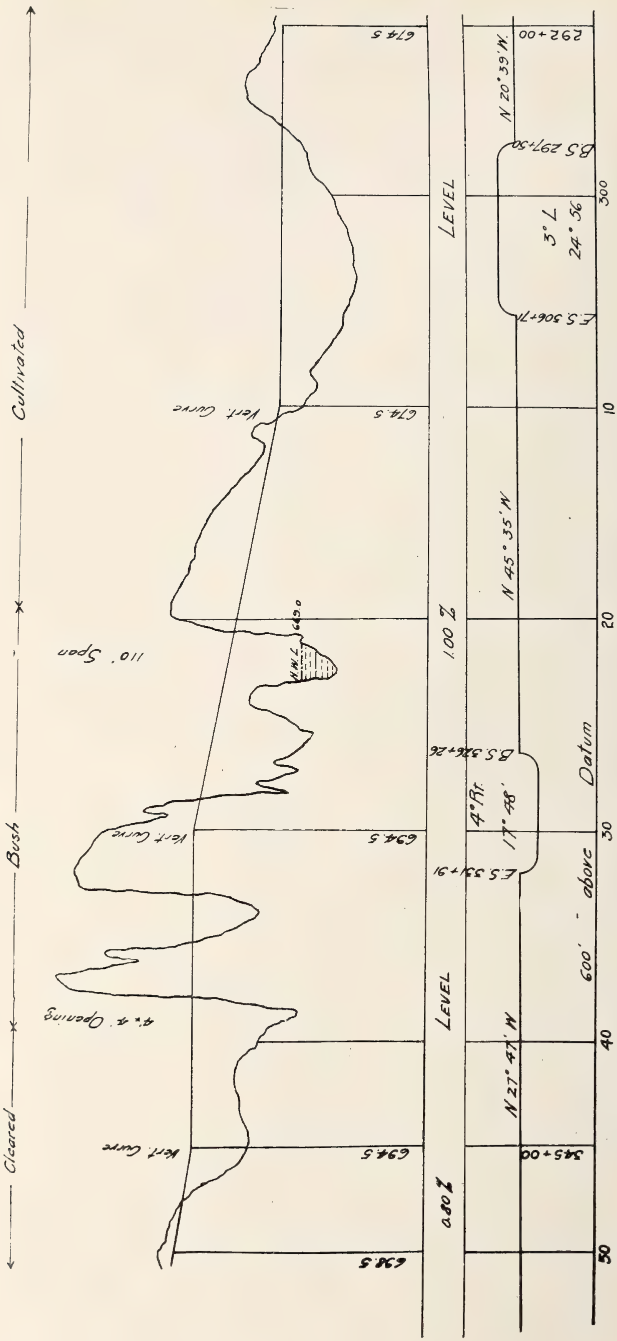
A few remarks will probably be in order here as to the outfitting of a party to be sent into the field in an unsettled district. It is customary for the members of the party to outfit themselves with boots and clothing. While surveys afford good opportunity for wearing out old clothes, these old clothes should be made of stout material if they would stand the wear and tear of rocks and bush. Good overalls, or, better still, whipcord clothing, give excellent service. Do not fail to supply yourself with strong, well-fitting boots, as nearly waterproof as possible. A good deal of walking falls to the lot of the members of the survey party in one day, and it is absolutely necessary that comfortable and substantial footgear be used. The supply of blankets will depend upon the section of country and the time of the year during which the survey is being carried on. Seldom does one find the members of a party lacking in ample supplies of the above-mentioned, but rather too often finds them, and especially the inexperienced ones, starting out, each with an outfit sufficient for himself and several others.

Amongst the general supplies there should be taken into the field a good, substantial, and not too large stationery box, preferably made of oak, and some useful form of collapsible drafting table, built of well-seasoned pine. That portion of the supplies, however, of most importance and requiring greatest care in selection is undoubtedly the food supply. Different cooks use different quantities of the same cooking materials, so that it is usually advisable to consult the cook in the purchases. Be it understood, however, that no party should venture into the field without an abundant supply of "long, clear," beans and prunes. No railroad line in this country has ever been brought to completion without the frequent application of these three national railroad builders. It may be said generally that one and one-half tons of good supplies are necessary for a party of eighteen men for one month's time. For details, Lavis on "Railroad Location" gives a very complete and reliable list. The Transcontinental Railway's book of instructions to engineers also contains a very complete list. In addition to the food supply there should also be a complete outfit of cooking utensils and general tools, together with a medicine chest.

In considering the actual preliminary survey, a few details of the methods of beginning the survey might be instructive. The true azimuth of the initial course is required as a basis for further calculation and reduction. This azimuth can best be obtained by an observation on the sun or polaris, or preferably both. It may also be obtained by tieing into some reliable land line of known azimuth, preferably a line established by the Dominion Lands Survey, since many of the Provincial Lands survey lines are very unreliable. A datum plane for the levels must also be established. Dominion Geographer James White's book of "Altitudes in Canada" will be found a most useful and convenient reference as a means of obtaining a starting point with the levels. Therein is contained a list of altitudes referred to mean sea level as datum, of all railway points, and of the principal rivers and lakes of Canada.

Preliminary Survey.

The reconnaissance survey will have confined the best location line to a given belt of country; in the preliminary survey the line is made to follow the particular ground within this belt which seems best adapted to the construction of a railway. This preliminary line is run in a series of chords or straight lines, changes in direction being introduced to fit the ground. These angular changes of direction are measured with the transit, the points of set-up being termed hubs or transit points. A continuous chainage begun with station 0+00 at the initial hub is carefully carried forward by the chainmen, station stakes being driven at each 100-foot point, and additional guard stakes marked with the chainage to the nearest tenth of one foot driven at hub points. The transitinan will record the chainage of each hub with the amount and direction of the angle turned off. From this data can be derived the information whereby the plan of the line as actually laid down in the field can be plotted in the office. The profile of the ground is fixed by the levels. The leveller will take readings at each station point and at all intermediate points where breaks occur in the general lay of the ground. Lastly, by means of



Profile Shewing Section of Location Line cross-sections or contours, the topographer will make a careful determination of the natural run of the ground on either side of centre line to given distances, depending on the nature of the country. He will also locate with reference to the centre line all river banks, roads, drainage, ditches, and in settled districts the position of all buildings within these fixed limits. In rough country where abrupt changes in the ground occur, the cross-section method can be used to best advantage since contour lines would lie too close to one another in such country, giving a plan likely to be somewhat confusing because of a multiplicity of lines. Nor will the contour method be as serviceable in very even country because of a lack of contour lines. In undulating country, however, such as we find largely in the prairie, no other method of topography is quite equal to contouring.

Only the most accurate transit and chainage work can be tolerated on the preliminary survey since the final location is laid down relative to this preliminary lines. A great deal of time, however, is often spent in unnecessary detail and accuracy in laying down the preliminary line to fit precisely particular sections of the ground. The preliminary survey of the entire proposed route should first be completed, since one section of a final location might be run to give easy curvature and light gradients, while at some other section of the line it would, for the same cost per mile, be utterly impossible to maintain these high standard of grades and curves.

The rate at which the preliminary surveys should be pushed through will depend entirely upon the nature of the country. The rate at which it is put through is often another question. In heavy bush a mile to a mile and a quarter is good work with a party of five or six axemen, while in open country, five to six miles constitutes a very fair day's work. In very rough mountainous country 3,000 feet of line run might represent a very hard and heavy day's labor, while in open country under most favorable circumstances seven or eight miles is occasionally run in one day. Through a very short-sighted policy it sometimes happens that the railway company will not make expenditures unless immediate and direct results be shown therefor; the party may be poorly equipped with supplies, may be poorly provided with transportation facilities and lastly the men as very often happens.

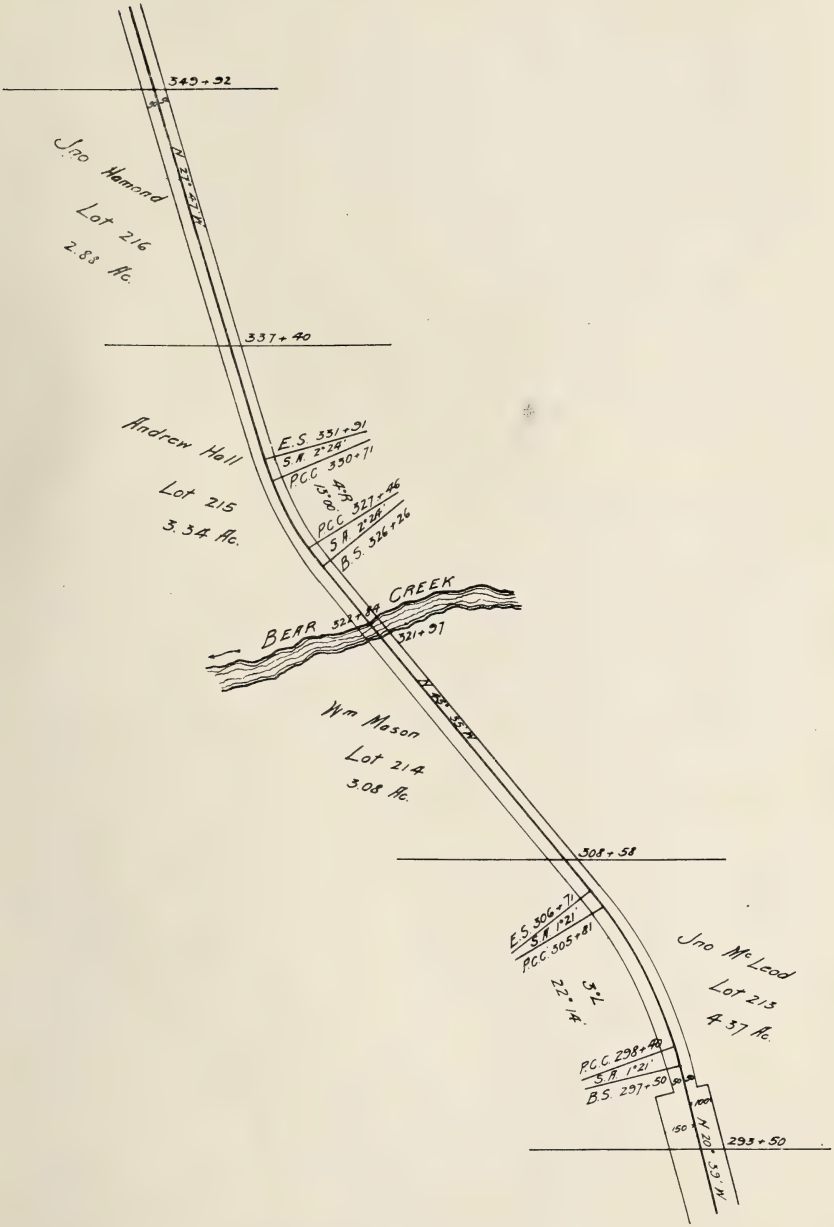
Before passing from the subject of preliminary surveys it would be well to consider briefly the methods employed in plotting the work in the office. The preliminary profile will be plotted on regular "profile paper." On it should be noted all water-courses with proposed openings, the nature of the country, wooded or otherwise, and the positions of all bench marks established. There is no alternative method of profile plotting. In preparing plans, however, we have a choice of methods. The scale of the plan will depend upon the nature of the country. In open easy country a scale of 400 feet equal 1 inch, will give a plan amply large for all purposes, while in rough localities a scale of 100 feet or 200 feet equal one inch, will be found more satisfactory. The system of latitudes and departures will be found most accurate and satisfactory in plotting the preliminary and other plans. It entails somewhat more work than does the "protractor" system, but errors are local not accumulative, as is the case with this latter method. Weather conditions will appreciably affect the plan paper, causing shrinkage or lengthening when the atmosphere is alternately dry or humid. The draughtsman should be careful not to allow errors to creep in from this source.

Final Location.

Let us now suppose the preliminary survey completed to the satisfaction of the engineer. There remains to be run now, only the final location line. Some very good location work has been done by laying down in the field, tangents to fit the ground, joining up the extremities with suitable curves. A much more reliable and more rapid method of obtaining a final location line has since come into general use, known as "projected location." With all the available information plotted on the preliminary plan, the engineer studies out this plan and profile, thus enabling him to lay down or project upon his plan the best possible line desired, always keeping well in mind the requirements of the completed road, low initial cost and cheapness in operation. In light open country it will be found to best advantage to locate or lay down on the plan the tangents best suited to fit the ground, connecting them up with easy curves. In rough country on the contrary it will be found more advantageous to fit the ground with the best suited curves, linking them up with tangents. This projected line which is now laid down in the field is called the location line. Frequently in rough country where errors in chainage creep in so easily it is found necessary to re-run sections of the location line to get the best suited ground. Such rerunning of line will be done most economically with the survey party in the field, and should not if avoidable, be left for correction to a small revision party which later may be put in the field. Revision should be reduced to a minimum in a well located line.

The location line will be laid out in a manner similar to that employed on the preliminary line with possibly one exception,—all tangents are joined up with regular railway curves. The levels will be taken as before, the leveller as well as transitman, booking any information which is likely to be of value later in obtaining a preliminary estimate of cost or such as may be of value in construction. The topographer should locate all land lines intersected by the location line, should obtain the lot numbers and names of owners, at the same time fixing the position of all buildings lying within the proposed right-of-way. He should further give particular attention to determining with reference to centre line the position of all water courses likely to have a bearing on the construction of the line.

Plan and profile should be made of the final location line em-



Section of Plan of Location Line

bracing all of the above information. The Dominion Railway Commission require that plan and profile of final location filed shall be to a horizontal or plan scale of 400′ = 1″ and a vertical scale of 20′ = 1″. On the plan there shall be shown the beginning and ending of each curve with its degree and total angle of curvature, the width of the right-of-way, all varying widths being indicated, the "plus" of every intersecting land line, lot numbers, owners' names, and area of the proposed right-of-way to be taken, the position of all buildings within the right-of-way, and all watercourses of consequence. A book of reference must be compiled giving all right-of-way information. This book of reference is usually attached to one end of the plan. The profile must show all grades and alignment notes, must indicate the nature of the country, and the proposed openings for all watercourses. High water levels for all important watercourses should be marked. All such plans and profiles should be certified to by the president or vice-president of the company, and by the company's engineer.

Grades.

A few remarks with regard to selecting the grade lines. It is usual in construction work to aim at as nearly as possible a balance between excavation and embankment quantities. But just as the lack of material from a cutting does not necessitate a low embankment and heavy grades, neither should good grades be sacrificed in an endeavor to prevent the wasting of material from cuttings. As regards changes of grade, it may be said definitely the summit of a grade should never occur in an embankment nor should the foot of a grade ever occur in a cutting.

Before leaving the question of final location, a few remarks on the standard railroad of to-day will not come amiss. The maximum degree of curvature for this class of road shall be three degrees per 100 feet of curve, all curves of sharpness exceeding 1° per 100′ of length being eased off to their tangents by means of the spiral of transition curve.* The maximum grade shall be 0.4′ per 100′ of length, and shall be compensated for curvature at the rate of 0.04′ per 100′ for degree of curve. The 0.4 per cent. grade represents practically a level line where this ruling grade comes within station ground limits, since the locomotive which can start its train on the level can maintain a speed of 15 miles per hour against this grade. Velocity grades exceeding the ruling grade are not objectionable where such are unavoidable. They are, however, worthy of considerable study by the engineer before making use of the same in his work.

A point of seemingly small consequence in running of railroad location lines but one which has considerable bearing on further developments is the treatment of the land-owners and their property, through settled districts. The company is, of course, liable to any damage to property accompanying the carrying forward of the survey, but a great many petty and unnecessary annoyances are often heaped upon the property owners through carelessness and disrespect. Landowners through whose property surveys may be carried should be treated with courtesy and respect, by the chief and party, while allowance should be made for the ignorance of the average property owner of such matters, and patience exercised therewith. The members of the location party are probably the first representatives of the railroad company with whom the landowner meets. His first impressions, the most lasting, will be formed from his acquaintance with the location party, and he will base his opinions accordingly. Careful treatment of property and courtesy towards the owners will make the work of the right-of-way agent much easier and more pleasant, and is a matter of economy worthy of consideration by the company. A story is told of a location party which was running line through a certain farmer's property. The farmer who was naturally inquisitive as to why these men should be on his property, went out to make enquiries of them. The chief answered him curtly that he held in his pocket a paper which gave him the right to enter in upon any property, public or private, at such time as suited him. The farmer made no reply, turned on his heel and sauntered back to the barnyard. Here he untied his bull and turned him loose into the field. The bull made straight for the party, who perceived him only in time to shin up some nearby trees. The men after waiting vainly for some time in hopes the bull would retire, shouted to the farmer to come and take the animal away. The farmer who could evidently appreciate the joke, shouted back the suggestion that the chief show his paper to the bull.

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*A minimum distance of 300 feet should be left between curves of opposite direction, while 500 feet is the minimum allowable distance between two curves of the same direction.

Estimating.

In closing, we give the details of a preliminary estimate of 100 miles of line actually located and constructed. Preliminary estimates are invariably exceeded. A solution to the difficulty might be found by applying in moderation the method of estimating machine shop work. Carefully estimate the cost of the work and multiply by two. In the present instance the final cost exceeded the preliminary estimate by an amount slightly less than 10 per cent.

PRELIMINARY ESTIMATE OF COST.

(a) Grading (including overhaul, piping and culverts)—	
50 miles at $1,650 per mile	$ 82,500.00
30 miles at $3,500 per mile	105,000.00
20 miles at $6,000 per mile	120,000.00
(b) Right-of-way—	
520 acres at $200	104,000.00
(c) Rails, fastenings and ties—	
11,500 gross tons rails and fastenings at $35	402,500.00

271,000 ties at 40c.	108,000.00
100 miles of tracklaying at $300 per mile	30,000.00
(d) Ballasting—	
300,000 cubic yards at 35c.	105,000.00
(e) Crossing plank, sign boards, cattle guards—	
70,000 F.B.M. hemlock at $30	2,100.00
8,000 F.B.M. pine at $40	320.00
(f) Fencing—	
68,000 rods at 85c.	57,800.00
640 gates at $5	3,200.00
(g) Bridge steel and masonry—	
300,000 lbs. steel at 5c.	15,000.00
1,000 cubic yards concrete at $10	10,000.00
(h) Timber trestlework—	
300,000 F.B.M. at $45	13,500.00
Drift bolts, dowels, washers, etc.	275.00
(i) Engineering (including location)	22,500.00
Total estimate of cost	$1,181,695.00
Estimated cost per mile	$11,816.95

It will be noted that the cost per mile of construction, about $12,000, must necessarily represent light work. Such was the case, the greater portion of the country through which the line passed being prairie-like in nature. The maximum allowable grade was a 1 per cent. compensated for curvature, while the sharpest curve employed outside station ground limits was 5° per 100 feet of length.

BOOSTERS AND THEIR USE IN STREET RAILWAY OPERATION.*

L. S. O'DELL

Boosters are a special type of generator and they are usually operated in a circuit for the purpose of adding to or subtracting from an e. m. f. already existing there. Generally the class of service on which they are employed calls for a machine which will carry heavy currents and at the same time generate a relatively small e. m. f. acting positively or negatively as required. In street railway service boosters are employed in connection with storage battery regulation and, to a less extent, as a means of preventing excessive drop at the outlying terminals of feeder lines.

A storage battery system may be used as an auxiliary in a power plant in either of two ways. If the plant handles both a power and lighting load, fairly steady peak loads may occur at particular times of the day. At such times a battery may be used to help the generators carry the load, the battery being recharged at some time when the load is light. Such a battery is also much used for lighting purposes at times when it is desirable to shut down the generators entirely. When, however, the load fluctuates within wide limits as is nearly always the case in street railway service, a storage battery system is used to equalize the load upon the generators, the battery helping out the latter when the load is high and being recharged when the load is light. The total load curve, Fig. 1, illustrates such a load. To attain these conditions a special regulation system must be installed in connection with the storage battery.

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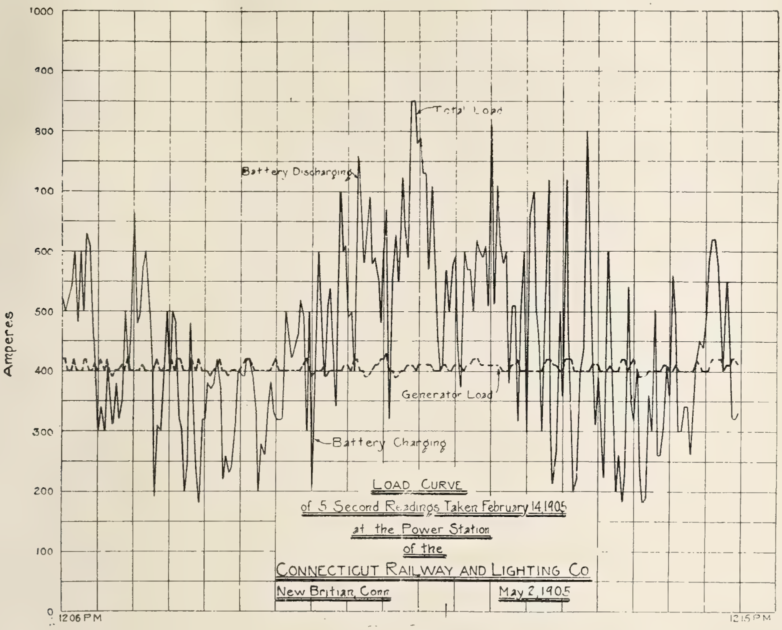
*Read before Electrical Club, Nov., 1909.

The e. m. f. of one fully charged cell on no load is about 2.05 and when discharging full current this falls to about 1.95 owing to internal drop. When the cell is being charged the internal resistance increases very much because of polarization and a final impressed voltage of 2.65 is necessary to fully charge the cell. Hence when a battery, composed of a large number of cells in series, is employed on intermittent service as in the former case mentioned, and connected in parallel with generators over constant voltage mains some method must be used to prevent the drop of battery voltage below that of the line. This may be done by switching in more cells as the voltage falls or by using a booster in series with the battery, the booster automatically adding the necessary voltage to that of the battery. Unless there is some means of increasing the line voltage, the battery



can only be fully charged by decreasing the number of cells in series so as to have 2.65 volts available for each cell or by using a booster in such a way that its voltage will be added to that of the line so as to give a voltage 2.65 times the number of cells. The latter is by far the more common method. In the second case mentioned above the load fluctuates often and the battery must be in continual operation. Such operation is only successful when a booster and automatic regulation system is used. Whatever be the load variations on the line, the generator load should be practically constant as indicated by the curve of generator loads, Fig. 1. Hence on overload the regulation should be such that the booster will not only make up the difference between battery and line voltage, but add a voltage to that of the battery which will be sufficient to enable the later to discharge such a current as will carry all the overload, that is the load in excess of the predetermined generator load. On underload the booster e. m. f should reverse and be of such a value that this e. m. f. along with that of the line will force enough current through the battery to hold up the load on the generators, which supply this current, to its proper value.

Boosters are usually driven by ordinary shunt motors but any source of power, such as engines or turbines, may be employed. Such is understood to be the case in all the diagrams of Fig. 2, where only the battery, the booster, and the regulation systems are shown connected across the mains. Diagrams *a, b* and *c* show cases of a shunt generator used for boosting service. Under such circumstances the booster is generally only used to help charge the battery and an end cell switch as shown in *c* is used to gradually cut in cells and compensate for voltage drop. Such a machine will not automatically reverse and hence can only be used on intermittent service. If the booster is used to assist discharge the field must be reversed. Diagram *d* shows a series generator used as a booster. With average line load, there should be no discharge from the battery and its e. m. f. should equal that of the line. Suppose the load increases and the line voltage falls. Current flows from the battery through the booster to the line and this current exerting the booster creates an additional e. m. f. in the booster armature, which aids the battery to discharge. If the line load falls and the line e. m. f. rises, current will begin to flow from the line through the battery, and the subsequent booster excitation added to the line e. m. f. helps to charge the battery. Hence this system will work on either intermittent or continuous service but it is unsatisfactory and seldom used. Owing to residual magnetism in the fields the booster e. m. f. is sluggish in reversing. Furthermore, unless the iron in the booster magnets is worked at very low intensities, field saturation and armature reaction, which is a serious feature in all boosters owing to the relatively large armature currents carried, will prevent the e. m. f. generated from being anywhere nearly proportional to the current variations. Diagram *e* shows a compound generator used as a booster. Its regulation is a little better than with the series but it is not automatic.

Diagrams *f* and *g* illustrate types of what are known as differential boosters. They are practically the same in each case, the shunt and series windings acting in opposition to one another. With average line load and line voltage, the magnetizing effects of the two evils balance and if the battery e. m. f. equals that of the line, as it should, no current will flow in the battery circuit. An increase of load causes the series coil to predominate and an e. m. f. is induced in the booster such as well assist the battery to discharge. On under load the shunt field predominates, the booster assists the line voltage to charge the battery and the generator load is increased by the amount required for this charging. Such a system works very nicely when the battery voltage equals the line voltage on average load. If these are not equal the battery will take too much or too little of the load according as its voltage is higher or lower than that of the line. To overcome this tendency a third coil is inserted in series with the booster armature so that it acts as follows: If the battery voltage is high, current will flow from the battery through the booster armature and this auxiliary field to the line. The polarity of this field is such that the consequent induced e. m. f. opposes the flow of current and prevents its attaining any disturbing value. When the line voltage is higher than that of the battery, this auxiliary coil holds down the current which in this case tends to flow from the line through the battery. The magnetizing effects of this auxiliary coil should be small in comparison with the others, for if not this auxiliary

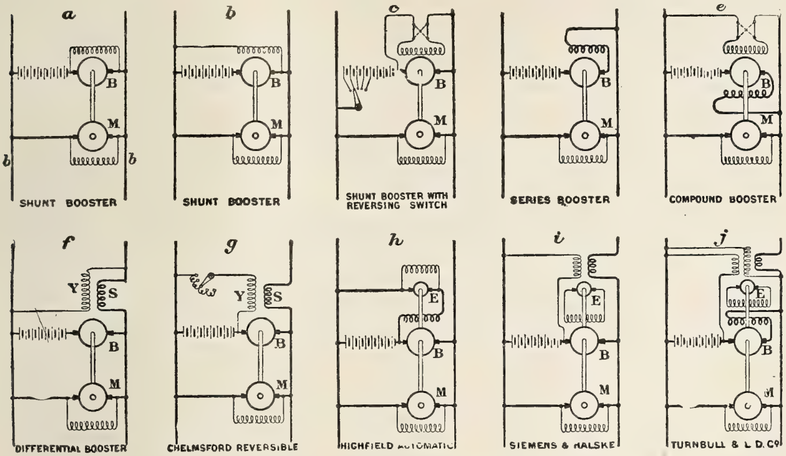


Fig. II. Types of Boosters.

coil will neutralize the action of the others and interfere with regulation. This it always does do to some extent.

In the differential types the booster is controlled by the simultaneous action of its three field coils. This construction involves a machine with very large fields and a considerable copper loss even though a shunt be used across the series field. Hence we have what are known as externally controlled systems, designed to avoid as far as possible the above difficulties. The last three diagrams illustrate the principle of the exciter-controlled booster set. The exciter is a much smaller separate generator usually driven by its own shunt motor. This machine excites a single shunt coil on the booster. In the Highfield automatic, the shunt field resistance of the exciter is so adjusted that the exciter e. m. f. balances that of the line and battery with average load under normal conditions. Then no current flows in booster battery or exciter circuit. Suppose the line load increases. The line voltage falls and both battery and exciter discharge onto the line. The current which now flows in the booster field generates an e. m. f. which assists discharge so that the battery will then carry the overload. On underload the exact opposite occcurs and the battery is charged. Should the battery get over or under charged, so long as the exciter e. m. f. is equal to that of the line, the battery will take care of the fluctuations of load. If the battery were overcharged on average load conditions it would tend to discharge both through the exciter and onto the line. This discharge current through the booster field generates an e. m. f. in the booster which opposes the tendency to discharge through it into the line and practically prevents that trouble so long as the line voltage holds up to normal. On undercharge the same line of argument will show that the apparatus automatically prevents the generators from charging the battery unless the line voltage rises above that of the exciter. Thus the same purpose is effected as that for which the third coil is employed on the differential types. In the last two diagrams of booster sets, the exciters are controlled by differential shunt and series windings just as in the first mentioned differentially controlled booster. The regulation is practically the same in both classes but the exciter controlled is the cheaper to operate owing to the decreased copper loss, the necessary field coils being much smaller. In the final diagram the extra shunt winding on the exciter and series winding on the booster, aid in giving better regulation, the series booster field being employed for the same purpose as in the differential types.

The Gould Regulation System, Fig. 3, is one much employed on this continent. This is an exciter controlled type but a counter e. m. f. generator as shown in diagram is also operated usually being driven by the same motor as the exciter. The field of this generator is excited by current from the main generators so that on average load the e. m. f. of the former balances that across the mains. Then no current flows in the exciter field and the rest of the system is inoperative provided the battery voltage equals that of the line. However, an increase or decrease in the generator load will cause current to flow in one direction or the other through the exciter field and hence current from the exciter energizes the booster so as to promote charge or discharge as required. The efficiency of regulation is unaffected by conditions of battery undercharge or overcharge, this very necessary condition following from the principle on which the system works. The object of the regulating apparatus is to keep the generator load constant at a fair average value. Any variation from this condition of affairs is at once corrected by the system so that in whatever state the battery charge may be, it cannot disturb the operation of the plant to any serious extent.

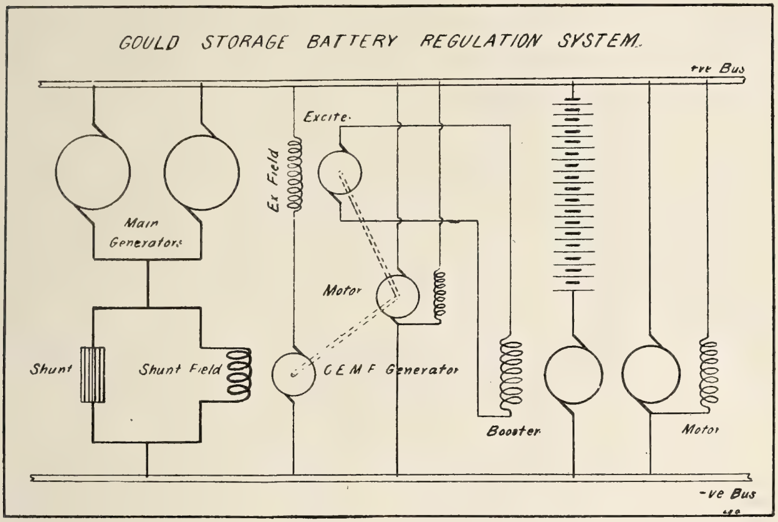


Fig. III. The Gould Battery Regulation System.

While the last system described gives a very efficient regulation, the exciter and counter e. m. f. generator with their driving motor introduce a considerable item of first cost and their operation involves a continuous though not very large expenditure of power. The Entz carbon pile regulator employs an externally controlled booster but the use of auxiliary generators is done away with. Fig. 4 illustrates this principle of operation. P and P^1 are carbon piles made up of a large number of circular sheets of carbon piled vertically. They are connected to the battery as shown. The solenoid about which line current passes acts against a spring at the other end of the lever and with average line current from the main generators the apparatus is so adjusted that the pressure on the two carbon piles is equal. Then the resistance of each will be the same and the drop across each pile will be half the battery e. m. f. The two parts of the battery and the two carbon piles constitute what is really a Wheatstone Bridge arrangement, and under the conditions above mentioned no current will flow in the branch containing the booster field. Any change in the generator load will, however, through the pull of the solenoid acting against the spring, cause the pressure on one of the piles to increase and on the other to decrease. This disturbs equilibrium and a current flows through the booster field in one direction or the other depending on whether overload or underload conditions exist. The consequent booster excitation aids to discharge or charge the battery as required. It should be noted that current is always flowing in the carbon piles. In a large station where a large booster is required a considerable current will be needed to energize the field of that machine, so it will be seen that the still greater current flowing continuously through the carbon piles involves a serious energy loss. Hence in some cases it has been found advantageous to use a separate exciter for the booster field and operate the exciter field by means of a carbon pile regulator.

All the systems described are more or less adjustable in their action, but this latter system is capable of a greater variety of adjustment than any other. All good systems can be set to carry any predetermined running load on the generators. This is done in the differentially controlled types by varying resistance in the shunt field circuit, in the Gould system by varying the shunt resistance across the counter e. m. f. generator field and in the Entz system by varying the tension of the spring which acts in opposition to the solenoid. Also, by the use of adjustable resistance in the field controlling circuits the sensitiveness of regulation may be varied at will, that is, the regulator may be set so as to maintain a steady load on the generators or may divide with them the load fluctuations in any desired proportion. Furthermore, the motion of the lever in either direction is limited by mechanical stops, so that when the overload or underload becomes so great as to send a current, to or from the battery, which may throw the circuit breaker on that line, further motion is prevented and any further load variations are carried by the generators. This is an important feature because the opening of the battery circuit breaker on overload is liable to throw a destructive load onto the machines or to throw their breakers, in which case total interruption of line service results.

The use of these regulation systems has only come into prominence during the last few years owing to the improvements in regulation obtained by some of the later systems. Most installations have been in connection with direct current street railway power plants where the loads are always extremely variable. Also in some other plants, such as those supplying power for electric drive in rolling mills, the load fluctuations are extreme and in the absence of some such regulation system the shocks due to sudden load changes would seriously decrease the life of the generators. A few storage battery plants are being operated in alternating generating stations but the rotary converters which must be interposed between the generators and battery form a considerable item of capital account. The more usual method especially in the case of large distribution systems is to install the batteries in substations. Then alternating current is generated and transmitted but at the substations is transformed to direct current, and used as such, the loads at the substations being equalized by a storage battery regulation system. This is also an expensive way of equalizing the load because of the number of battery systems and the consequent cost of maintenance. In both cases the load on the generators can be held practically constant. Such regulation would be very useful in the case of hydroelectric generating stations since it would practically dispense with the necessity of water-wheel governors. At all events the demands made upon such governors would be greatly reduced and the danger attendant upon their failure minimized.

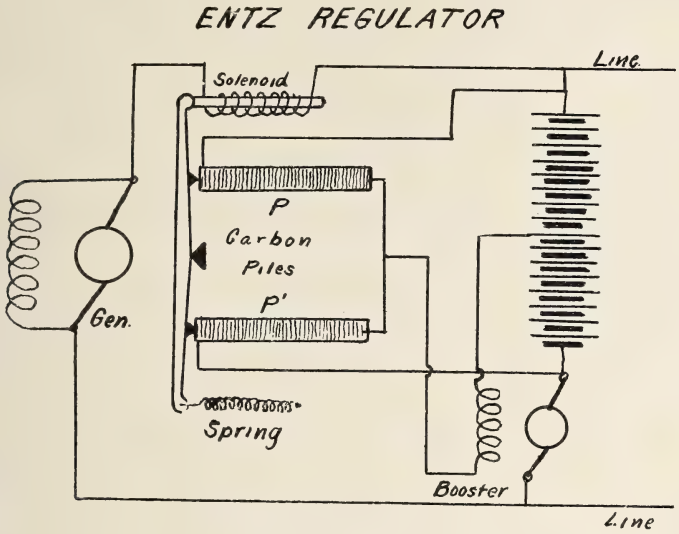


Fig. IV. The Entz Carbon Pile Regulator.

Besides doing away with load fluctuations and their incident wear and tear upon the generating machinery, the use of such systems carries with it other advantages. In the construction of new stations, the plant need only be of such a size that the generators will carry the average power to be delivered, and at times of peak load the station with the aid of the battery will carry far more than its generator capacity. This decrease in size of steam and electrical plant brings with it a decreased cost of maintenance. The machinery may also be operated at a load at which its efficiency is a maximum and both these latter points effect a continuous saving on the fuel bill.

Where such systems are installed in plants already operating the advantages derived follow much the same lines. They are often put in where increased demands for power have caused peak loads in excess of the generator capacity. Such a plant will obviate danger of burned-out armatures and prevent the opening of the circuit breaker when sudden load fluctfuations occur. It is often found that with a previously overloaded plant, part of the plant may afterwards be held in reserve or one unit after another may be shut down and the whole plant rebuilt or thoroughly renovated. The batteries also enable small railway lines which discontinue service during a part of the night to carry a lighting load all night with all the machinery shut down.

As previously hinted, boosters have another and entirely different use in connection with street railway operation. The drop on long feed lines especially at times of the day when the traffic is heaviest may go beyond its permissible limits and if over-compounding be resorted to, the voltage in the outlying parts of the system may be kept up, but the station voltage will become abnormally high. If a booster be placed in the feeder circuit and so adjusted that it will give boost equal to line drop the voltage at the remote terminal of the feeder line can be held up to that of the station. Negative boosters may also be used to compensate for drop upon he return circuit. With such a system the voltage generated at the station is really that of the generators, whose voltage is impressed on the line at the station and in addition the sum of the line drops on feeders and return circuits. This can only be done at the expense of extra driving power and the all important question is whether it would be better to use a booster or to install a heavier feeder line which is the only alternative by which excessive line drop may be prevented. On the one hand we have the continuous bill for the extra power and on the other hand a greater capital expenditure for the heavier copper line. It is found that in practically all circumstances a booster is an economical proposition only when it is used to prevent an excessive drop due to peak loads occurring for a few hours a day. A line drop which will make the booster a necessary auxiliary under average load conditions is never justified.

WATER COLUMNS FOR DEEP LEVEL MINES.

E. J. LASCHINGER, M.E., B.A.Sc.,* (Toronto)

The question as to the proper size for water columns for mines is one that always awaits decision when the details of mine equipment have to be decided.

The total cost of delivering the mine water to the surface may be considered as being made up of two parts:

1st. Actual cost of pumping or power cost.

2nd. The interest and redemption value of the pipe, plus maintenance of the pipe line.

The smaller the pipe the more power lost in frictional resistance to flow and the cheaper the pipe; the larger the pipe the less the power lost in friction and the greater the cost of the pipe. There must therefore be some size of pipe which will make the total cost a minimum for any given case.

A little reflection will show that the actual cost of raising the water against the static head does not enter into this question of pipe diameter, since that cost is a constant upon which size of pipe has no influence; so, also, regarding the cost and maintenance of the pump itself, because in any case the permissible amount of friction head is so small compared with the static lift that pumps need not be constructed stronger or made more expensive than is necessary, assuming only the static head with the usual safety margin. It is evident that the time of pumping has a bearing upon the size of pipe, for if pumping at a uniform rate goes on continuously, more total power is lost per day than if pumping at the same rate for only one shift per day.

The author's endeavor in this short paper has been to formulate expressions giving the average cost of water columns for depths up to, say, 2,000 ft. vertical, in terms of the diameter, and also the cost of horse-power lost in friction in terms of diameter, quantity of water, and time of pumping. Having obtained mathematical expressions for the total cost or value of the transmission line and the transmission losses in terms of the diameter of pipe and other factors, this equation is solved by the usual rules for finding minimum values, and that diameter deduced which will make the total transmission cost a minimum. This, then, gives us what may be called the most economical size of pipe.

Pipe Cost and Value.

A good heavy pipe for a pump column for high lifts will cost erected complete on the Rand:

$$s = d^{1.25} \qquad (1)$$

where s = cost in shillings per foot.

d = diameter in inches.

Table I herewith shows costs according to this formula for various sizes.

---

*President South African Association of Civil Engineers.

WATER COLUMNS FOR DEEP MINES

Size Inches.	Shillings per foot.	Size Inches.	Shillings per foot.
2	2.38	8	13 45
2½	3.14	9	15.59
3	3.94	10	17.78
3½	4.79	11	20.04
4	5.66	12	22.39
4½	6.55	14	27 09
5	7 48	16	32.00
6	9.39	18	37.08
7	11.39	20	42.30

Cost includes prime cost of pipe, flanges, joints, valves and fittings, bolts, erection, supports, engineering fees, administration charges.

VALUE OF PIPES

Interest=6% per annum.
Redemption=3½% Sinking Fund=
15.26% on 6 year's life.
6 84% " 12 " "
3 53% " 20 " "
Maintenance
5% " 6 " "
3% " 12 " "
1% " 20 " "

TOTAL VALUE FOR PIPE

On 6 year's life	26.26%	Per Annum of Capital
" 12 " "	15.84%	
" 20 " "	10.53%	

The total cost of the pipe line will therefore be:

$$S = \frac{Ld^{1.25}}{20} \tag{2}$$

where S = total cost of pipe in £
L = length in feet
d = dia. in inches.

The real continual cost of the pipe line will depend upon the interest and redemption value of the capital cost, plus the cost of maintenance

$$J = \left(\frac{i + r + m}{12}\right) S. \tag{3}$$

J = continual cost of pipe line in £ per month.
i = interest—annual.
r = redemption—annual.
m = maintenance—annual.

Take interest at 6 per cent. per annum.

Take redemption as a sinking fund bearing 3½ per cent. interest per annum, and taking three cases of pipe life of 6 years, 12 years, and 20 years respectively.

Take maintenance as—

5% per annum for a 6 years' life of pipe
3% per annum for a 12 years' life of pipe
1% per annum for a 20 years' life of pipe

For the three cases assumed we would have, therefore, the following values of J in equation (3):—

For pipe life of 6 years—

$$J_a = 0.0011\ Ld^{1.25} \tag{3a}$$

For pipe life of 12 years—

$$J_b = 0.00066\ Ld^{1.25} \tag{3b}$$

For pipe life of 20 years—

$$J_c = 0.00044\ Ld^{1.25} \tag{3c}$$

Friction Loss and Power Cost.

The power lost in friction is found by multiplying the weight of water pumped per second into the time of pumping and the friction head. The friction head is given by the well-known formula:

$$H = z \frac{L}{D} \frac{v^2}{2g} \qquad (4)$$

where H = friction head in feet
z = co-eff. of friction
L = length of pipe feet
D = dia. of pipe feet
v = velocity of flow in feet per sec.
g = acceleration of gravity = 32.1.

From Prof. Unwin's investigation* of the best experiments on flow in pipes somewhat rough or incrusted, the author deduces:

$$z = \frac{0.044}{D^{0.16}} \qquad (5)$$

Assuming that a cubic foot of water weighs 62.5 lbs., expressing velocity in terms of quantity and diameter, and combining equations (4) and (5), we find that the horse-power lost in friction is:

$$P = 46.75 \frac{Q^3 L}{d^{5.16}} \qquad (6)$$

where P = horse-power lost in friction
Q = quantity in cub. ft. per sec.
L = length of pipe in feet
d = dia. of pipe in inches.

Assuming that electric pumps are used giving a combined motor and pump efficiency of 74.6 per cent., so that the cost of an electrical unit input represents the cost of a horse-power hour in energy delivered to the water, we would have:

$$c = \frac{kh}{240} \qquad (7)$$

where c = cost of water horse-power in £ per mo.
k = cost of electrical unit in pence
h = number of hours pumping per month

For the case of electric power at 0.6d. per unit:

$$c_1 = 0.0025h \qquad (7a)$$

For the case of electric power at 1d. per unit:

$$c_2 = 0.0042h \qquad (7b)$$

Combining equations (6) and (7), we have for the total cost of frictional losses where power cost 0.6d. per unit:

$$C_1 = 0.1169 \frac{h\ L\ Q^3}{d^{5.16}} \qquad (8a)$$

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*A Treatise on Hydraulics—Unwin, A. & C. Black, London, 1907, p. 217.

and when power costs 1d. per unit:

$$C_2 = 0.1963 \frac{h\ L\ Q^3}{d^{5.16}} \qquad (8b)$$

where C_1 and C_2 represent total loss in £ per month.

The total continual cost of transmission may therefore now be written:

$$X = J + C \qquad (9)$$

Inserting letters K and M to represent the numerical values in equations of series (3) and (8):

$$X = K\ L\ d^{1.25} + \frac{M\ h\ L\ Q^3}{d^{5.16}} \qquad (10)$$

Setting the first differential ratio (assuming d as the variable) equal to zero, we get a condition of minimum:

$$\frac{dX}{dd} = 1.25KLd^{0.25} - \frac{5.16MhLQ^3}{d^{6.16}} = 0 \qquad (11)$$

Therefore:

$$d = \left(\frac{5.16}{1.25}\frac{M}{K}\right)^{0.156} h^{0.156} Q^{0.468} \qquad (12)$$

Where d represents the diameter in inches of the most economical size of pipe:

h = number of hours of pumping per month

Q = rate of pumping in cub. ft. per sec.

The sizes of pipe for the various conditions have been calculated and plotted in diagrams 1 and 3 for different cases. These diagrams will give by inspection the proper size with sufficient accuracy for general use.

Diagram 3 has been prepared to show graphically the costs involved in transmission losses for one set of cases. It will be seen that the curve showing the total cost of transmission has only one point of interest, and that is the point of minimum loss. It is also instructive to note that the losses do not increase rapidly on either side of the true economical diameter, but that it is best to err on the side of making the pipe slightly larger rather than smaller than the true economic size.

A few comments on points of interest may be noted:—

(1) Although these calculations have been made on the cost of pipe as given in Table I., a variation in price of pipe does not seriously affect the result, seeing that the diameter varies approximately as the 6th root of the cost. If piping as erected actually costs 50 per cent. more, the economical diameter is only 6 per cent. less, or if the actual cost of installation is one-half of that assumed, the diameter should be only 11 per cent. greater. The cost of lead-lined pipes for a head of 1,500 feet would be about double the costs assumed; this would make the economical diameter 10 per cent. less than the sizes shown in the diagrams.

(2) Higher velocities are permissible in large pipes than in small pipes.

(3) Length of pipe does not affect the economic size.

(4) With cheaper power it is advantageous to allow a greater frictional loss and save on the capital cost of installation.

(5) In temporary piping installations or with pipes having a short life it is economical to put in smaller pipes than when pipes have a long life.

(6) For continuous pumping pipes should be larger (other conditions being equal) than when pumping is intermittent.

(7) The sizes of pipe for different rates of pumping as given by the diagrams allow ample margin, since the co-efficient of friction has been taken for incrusted pipes and not for new pipes. Actual experience has, however, shown that frictional loss soon approximates to the condition assumed.

(8) With the sizes of pipe as given by the diagrams the frictional loss is small, or in other words the efficiency of pipe transmission is high, as the following table (II.) will show:

TABLE II.

Percentage ratio between frictional loss and static head for vertical lift.

Power Cost....	0.6d. per K. W. hr.				1d. per K. W hr.			
Pipe Life......	6 Years		20 Years		6 Years		20 Years	
Pumping Time...	1 shift	3 shifts	1 shift	3 shifts	1 shift	3 shifts	1 shift	3 shifts
At 1 c. f. sec...	3.73	1 54	1.78	0.74	2.46	1.17	1.01	0.48
" 4 c. f. sec...	2 10	1.00	0.87	0.41	1.38	0.66	0 57	0.27

(9) Since the length of pipe does not affect the proper diameter, it follows that for a certain static lift it is economical to allow more total frictional loss in incline shafts than in vertical shafts in the direct proportion that the length along the incline bears to the vertical depth; in other words, in the inverse ratio of the sine of the angle of dip.

(10) It will be seen from an inspection of the diagrams that the most economical velocities of flow are quite moderate. With power at 0.6d. per k.w. hr. and continuous pumping the velocity range lies between 2½ to 4 ft. per sec., and with power at 1d. per k.w. hr, between 2 and 3½ ft. per sec. for ordinary sizes of pipe.

In conclusion, the author would say that there are very many points worth investigating in connection with this important subject of deep-level pump columns and pumping generally. Numerous instructive experiences might be related by those who have had to do with the design, installation and working of deep-level pumping plants, which would form the basis of an interesting and valuable discussion before this Association. This note has been confined to the study of only one of the many points involved in the design of plant, in the hope that the conclusions may be of some service to engineers and the mining industry.

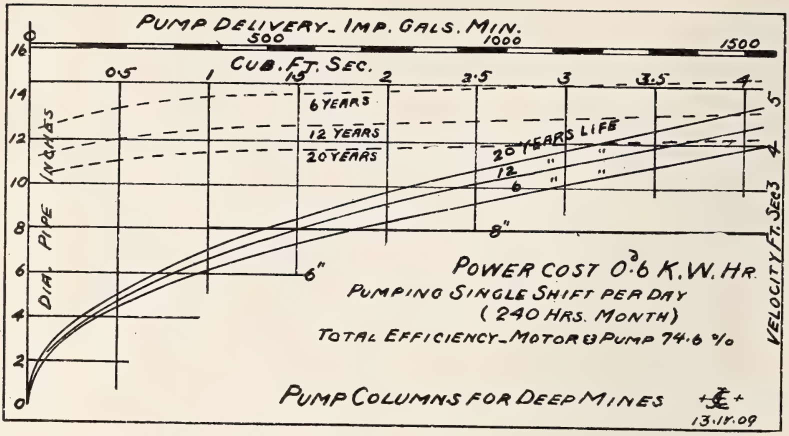

Fig. 1

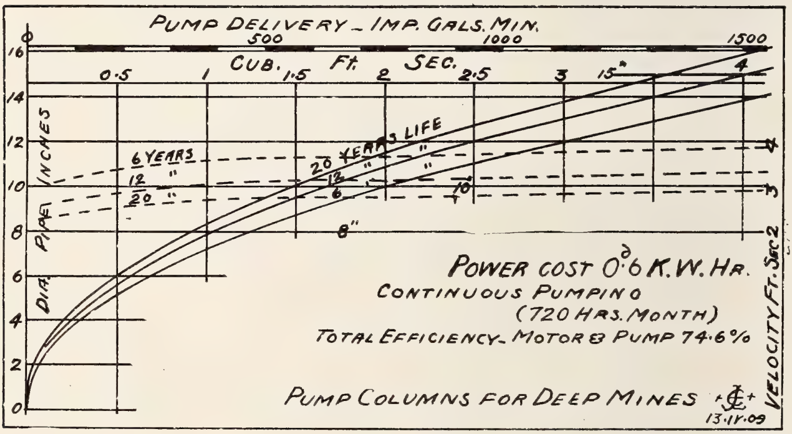

Fig. 2

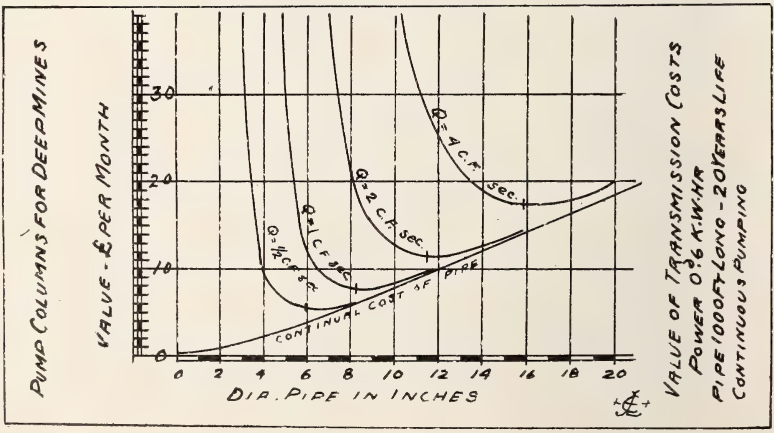

Fig. 3

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Editorial

Last Year's Dinner

Two events occurred in the last few years which served to bring the Faculty of Engineering of the University of Toronto most prominently before the engineering interests of Canada. One was the appointment of Dean Galbraith to the Quebec Bridge Commission; the other, was the last Engineering Society dinner. On that occasion the Canadian Society of Civil Engineers were the guests of the Engineering Society. Engineers were present from all quarters of the Dominion. To some of these the University of Toronto was but a name. Some knew the University in a way, but their ideas of its size and importance were very hazy. Some were graduates of sister universities and slightly prejudiced against us. Some were our graduates but whose interest through long absence had grown cold. All were astonished at the magnitude and excellence of our Engineering Faculty and carried with them a true and favorable idea of our university.

This Year's Dinner

This year it was expected that the new Thermodynamics and Hydraulic Laboratories would be opened with considerable ceremony. It was planned that the industrial interests of the country, as represented by the Canadian Manufacturers' Association, should be invited; that prominent speakers would be present; that a strong effort would be made to bring the manufacturing interests more closely in touch with the University; that they would be shown exactly what is being done to fit our young men to become the engineers of the future. These things and more were planned, but unfortunately the Board of Governors refused to find the money necessary to finance the undertaking.

However, part of the plan was saved from the wreckage. The Engineering Society have decided to ask some two or three hundred members of the Canadian Manufacturers' Association, interested in engineering works, to be the guests of the Society at their annual dinner. While the dinner cannot possibly have the effect that the "opening" would have had it is hoped that this will be a great advance in interesting the manufacturers in the University.

WHY A CERAMIC SCHOOL SHOULD BE ESTABLISHED IN CANADA

By D. O. McKinnon

Secretary Canadian Clay Products Manufacturers' Association

For several years the clay-workers of Canada, working through their national association, have been agitating for a Ceramic School in Ontario or, failing that, a Course in Ceramics at the University of Toronto.

Two years ago Prof. Ellis, of the School of Practical Science, with Messrs. S. J. Fox, M.P.P., and Wm. McCredie, two practical men, were sent to Columbus, Ohio, to visit the Department of Ceramics, Ohio State University, with a view of reporting on the advisability of establishing a similar course in connection with the university here.

A report on the matter was prepared by Prof. Ellis. This report, which was favorable to the proposal, was approved by the Faculty and the University Senate, but when placed before the Board of Governors it did not receive favorable consideration because, as one of the members of the Board subsequently put it, in speaking to a prominent clay-worker, it was thought "not necessary for a man to attend university for four years in order to learn how to make bricks."

The decision was not a surprising one, in view of the fact that none of the members of the Board of Governors of Toronto

University were familiar with the ceramic industries, or for that matter with the meaning of the word, "ceramics," in the broader sense of the term.

It is, we believe, well within the province of this paper to make clear what is desired by those behind the agitation for a course in ceramics, to emphasize what a Department of Ceramics in connection with the University of Toronto could do for the Province of Ontario, which supports that institution, and finally to suggest how such a course could be added to the curriculum of the university without very great expense either in equipment or maintenance.

This article will be confined to an explanation of the course desired and of the work it might accomplish.

According to Webster the word, "ceramics," means "the art of making things of baked clay, as pottery, tiles, etc." As pointed out in an article in this issue by Mr. Harry de Joannis, the ceramic art is the most ancient of all industries. Clay tablets and cylinders were the writing implements of Babylonia and Assyria. Clay wares (pottery) constituted one of the chief expressions of Greek art. In almost every country in the world except Canada, pottery of artistic nature is made. In England, France and Austria exquisite china and porcelain ware are produced. China, Japan, India, Persia, produce ware of beautiful design and workmanship.

Even more important than the artistic ceramic products, however, are the purely commercial, such as building brick, tiles, sewer pipe, terra cotta, etc. These, too, are made in almost every country in the world, Canadian products comparing favorably with the best.

The student taking a course in ceramics must "learn the art of mechanical drawing, know the laws and rules of mechanics, heat, light, and electricity, the rules of practical calculation as well as of higher mathematics, the laws of chemistry, the teachings of geology; he is asked to survey land, to examine machinery, to work in the blacksmith, carpentry and machine shops, and finally to do practical work in the clay-working shops and laboratories so that he may understand the qualities of clay, limestones and other rocks and be able to produce ceramic products from brick to porcelain, glasses, enamels and cements."

According to the latest figures available the attendance enrollment of students in the Department of Ceramics, Ohio University, was as follows:

Freshmen	17
Sophomores	20
Juniors	21
Seniors	13
First year, short course	8
Second year, short course	8
Specials	3
Total	90

The work of all the students is under the direction of Prof. J. Orton, jr., three other practical ceramists of high standing being on his staff.

We submit that, in view of the work done at Columbus,—remembering that four other universities in the United States offer similar courses—there is little need of detailed argument as to the need of such a course in connection with the University of Toronto.

Suffice it is to say that clay-working constitutes one of the seven leading mining industries of Canada; that the price of building brick, for instance, ranges from $7.00 per M to over $27.00 per M, according to quality; that the demand for the higher quality exceeds the domestic supply and that the domestic supply is limited by the lack of experts rather than the lack of necessary clays or machinery.

The industries that do not flourish in Canada call even more loudly for highly trained ceramists than those that do exist. For instance, according to Dr. J. O. Orr, manager of the Canadian National Exhibition, one of the largest manufacturers of porcelain in England, has decided to establish a plant in Canada. To do so he must not only bring with him many workmen, but all his experts on whose shoulders will rest the responsibility for the success of the Canadian branch. Unless Canadians be trained in ceramics the successors and assistants to the experts must for all time to come be foreigners.

We venture to assert that there is not in Canada a man sufficiently familiar with the facts to say that there is not in Canada the necessary clay for making many lines of ceramic ware not made in Canada. Yet the impression prevails that such clay does not exist. It would not take many years for a small body of students well trained in chemistry and geology to secure, through the channels of the work they engage in after graduation the practical knowledge of the needs of the clay-worker, necessary to enable them to "make two blades of grass grow where one grows now," or, in other words to so improve methods of clay product manufacturing that the industry will grow beyond the manufacture of building materials till china and porcelain ware, enamelware and stoneware shall be made here as in other countries and the industry shall take its rightful place as one of the most highly specialized in the country.—From the Canadian Clayworker.

C. J. Townsend, '04, is chief mechanical engineer for the Arnold Co., Chicago.

A. T. C. McMaster, '01, is in charge of a field party for the Hydro-Electric Commission in the Guelph District.

The profession of Land Surveying becomes by law a close corporation in Saskatchewan early this year. J. R. L. Parsons, '01, and A. J. MacPherson, '93, were the men prominently behind the movement.

THE ENGINEERING SOCIETY

The Annual Dinner of the Engineering Society will be held in the University Convocation Hall on Wednesday evening, January 19th, 1910. Encouraged by the remarkable success of last year's dinner, when some two hundred members of the Canadian Society of Civil Engineers were the guests of the Engineering Society, the Executive have decided to, if possible, eclipse all previous efforts.

This year the members of the Canadian Manufacturers' Association, interested along engineering lines, will be the invited guests of the Society. Unfortunately there is no pronounced bond between the manufacturing industries and the University. It is hoped that this dinner will pave the way to a more intimate connection.

The speech list this year will be considerably curtailed. The efforts of the undergraduate orators will be limited, the number of toasts will be reduced. Quality will more than make up for the reduction in quantity. It is expected that the speakers will be the President of the Canadian Manufacturers' Association; M. J. Butler, C.E., Deputy Minister and Chief Engineer, Department of Railways and Canals; Dr. J. A. MacDonald, and President Falconer.

Undergraduate singing on a scale never before attempted has been arranged. The male chorus under Mr. C. Bush, which added so greatly to the enjoyment last year, will again be present. Topical songs, and parodies will be rendered. All signs point to not only the most interesting and instructive but to the most enjoyable dinner in a long series of unbroken successes.

Special efforts are being made to interest all the graduates to be present. Should "Applied Science" reach anybody to whom a special invitation has not been sent, and who can possibly be present, they are urged to do so. Special tables will be provided for the graduates. Seats will be reserved for all sending in requests for same along with the price of their ticket not later than Tuesday, January 18th. The tickets are $1.50. All arrangements are in the hands of the Executive Committee of the Engineering Society.

Every person connected with the faculty, past or present, owes it to himself and to the Society to use every effort to make this dinner the success it is bound to be.

This is the only function of the Engineering Faculty that has the full support of the Society. It has always been looked forward to by the undergraduates as the one event of the college year.

Every undergraduate should turn out and present to the graduates and guests the fact that not only is the *esprit de corps* of the "school" still present, but is every year increasing. A dinner which is not bigger and better than its predecessor cannot, in the light of past events, be considered a pronounced success. It is therefore necessary that all undergraduates should seek to preserve the traditions of the "school."

THESES.

The theses for the degree B.A. Sc., were called earlier this year than ever before. The following is a list of those submitted by the men seeking this degree:—

Anderson, R. M.—Street Pavements—general principles and common forms of construction.

Black, W. D.—Elevators—The evolution from the simple hydraulic to the modern hydraulic; plunger and electric traction elevators for high buildings.

Barry, W. H. — Steel Construction—Foundations, columns, beams, girders, and roof trusses.

Burns, J. D.—Industrial Alcohol—and Its Use in Engines.

Blackwood, W. C.—Voltage Regulation—The need for and advantage of voltage regulation in case of lighting and power circuits; a description of some of the more modern methods of regulation in A. C. and D. C. circuits with special reference to Rotary Converters and Electric Furnaces.

Black, G. E.—Modern Steam Locomotive Improvements—A description and advantages of the following improvements—the piston valve, the Walschaut valve gear, the automatic stoker, the compound locomotive, types of superheaters.

Bowen, C. H.—The Transformer—being a synopsis of the general principles; application of vector diagrams and description of the general construction of the constant potential transformer.

Cunningham, R. H.—Single Phase Locomotives—A description of the electrical equipment of the modern single phase locomotive, including control, motors, collecting devices and general maintenance.

Cooch, H. A.—Mercury Arc Rectifiers—A collection of conclusions on the theory and practice of mercury vapor apparatus used for rectification from alternating to direct current.

Evans, F. L.—Highway Construction—Location, drainage and surfacing.

Frost, D. R.—Fuel Economy in Steam Plants—Principles; combustion and fuel; effects of design of furnaces, boilers, etc., on economy; methods of firing and fuel saving appliances.

Ferguson, J. T.—The Gas Engine—Theoretical treatment of the horizontal four cycle type.

Ferguson, J. B.—Grain Bins and Elevators—Experimental data on grain pressures in deep bins; the design and equipment of elevators.

Falconer, F. S.—Topography—Triangulation and plane table work.

Flanagan, O. L.—Water Supply—Sources, methods of collecting and storing, purification, distribution.

Flint, C.—Masonry and Earthen Dams—Design and methods of construction.

Gunn, W. W.—Reinforced Concrete Dams—Their design and methods of construction.

Green, G. E. D.—Dams—An investigation into the cause of failures.

Harvey, D. W.—Cost Keeping—The methods and importance of itemized cost keeping to show the efficiency of management on construction.

Holmes, A. E.—Steam Turbines—Their operation and characteristics; comparison with other forms of steam engines.

Hughes, C.—Some Developments in Steam Locomotives.

Hagarman, F. G.—The Electric Incandescent Lamp—Its development from its earliest experimental stage to the high efficiency Tungsten lamp.

Hoshal, G. C.—Macadam Highways.

Irwin, H.—Modern Refrigeration Machinery—Description of different methods in general use and the machinery used in each method.

Isbister, J.—The Induction Motor—Outline of construction, operation and application.

Jackes, G. P.—Storage Batteries—Outline of various systems used; their application, installation, testing, care and maintenance; booster systems, etc.

James, E. W. D.—Water Supply—Its sources, quality and consumption.

Johnston, C. C.—The Design of Plain Concrete and Masonry Retaining Walls.

Johnston, C. E.—Concrete Piles—Construction and bearing power.

(To be concluded in February issue.)

LONDON S. P. S. CLUB.

The second annual dinner of the London S. P. S. Club was held at the Tecumseh House, London, on December 27th, 1909.

After the usual sumptuous repast Mr. John Stiles, the chairman, proposed the toast to the King.

"The Profession" was proposed by F. Brickenden and responded to by A. C. Spencer, '08.

P. G. Welford proposed the toast City of London, which was answered by E. J. Sifton, the City Electrical Engineer. The other speakers were W. C. Ferguson, L. S. O'Dell and R. H. Cunningham.

The following officers were elected for 1910:
Hon. President—Prof. R. W. Angus.
President—E. J. Sifton.
First Vice-President—F. Brickenden.
Second Vice-President—R. H. Cunningham.
Secretary-Treasurer—G. W. F. Wright.
Grad. Rep.—John Stiles.
Undergrad. Rep.—H. MacKenzie.

It is likely that this association will form the nucleus of a Engineers' Club of London.

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